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Joint Polar Satellite System (JPSS) Operational Algorithm Description (OAD) Document for Ozone Mapping and Profiler Suite (OMPS) Total Column (TC) Sensor Data Records (SDR) Software

For Public Release

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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) Total Column (TC) Sensor Data Records (SDR) Software JPSS Electronic Signature Page

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Preface

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

Any questions should be addressed to:

JPSS Configuration Management Office
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Change History Log

Revision	Effective Date	Description of Changes (Reference the CCR & CCB/ERB Approve Date)
Original	06/03/2011	This version incorporates **474-CCR-11-0093** which converts D39310, Operational Algorithm Description (OAD) Document for OMPS Total Column (TC) 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-11-0248:** This version baselines 474-00077, Joint Polar Satellite System (JPSS) Operational Algorithm Description (OAD) Document for Ozone Mapping and Profiler Suite (OMPS) Total Column (TC) Sensor Data Records (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 474-00077, JPSS OAD Document for OMPS TC 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	07/10/2013	**474-CCR-13-1101:** This version authorizes 474-00077, JPSS OAD Document for OMPS TC SDR Software, for the Mx 7.1 IDPS release. Includes Raytheon ECR-ALG-0039/PCR033756: OAD: Implement 474-CCR-12-0776 (OMPS TC Dark Table Update - Fast Track) (ADR 4879) in section 5.0.
Revision D	11/06/2013	**474-CCR-13-1288:** This version authorizes 474-00077, JPSS OAD Document for OMPS TC SDR Software, for the Mx 8.0 IDPS release. Includes administrative changes authorized by interoffice memo and Raytheon PCR034548; OAD: PRO: 474-CCR-13-0883: OMPS TC Stray Light Correction and LUT - DR 4907, in section 2.1.2.2.4.
Revision E	01/29/2014	**474-CCR-14-1517:** This version authorizes 474-00077, JPSS OAD Document for OMPS TC SDR Software, for the Mx 8.1 IDPS release. Raytheon PCR035819; OAD: PRO: 474-CCR-13-1192: Wavelength Shift Adjustment for TC EV SDR Measurement - DR 7259, in new section 2.1.2.3.67.
Revision F	09/10/2014	**474-CCR-14-1976:** This version authorizes 474-00077, JPSS OAD Document for OMPS TC SDR Software, for the Mx 8.6 IDPS release. Includes Raytheon PCR039559; Child: PRO: OAD: CCR-14-1766: OMPS TC Documentation Update for Obsolete Waveflag and Radflag

		- DR 7613 in Table 40. Also includes Raytheon PCR041079, CHILD: PRO: OAD: 474-CCR-14-1879: OMPS TC Stray light code and LUT update - DR 7387, in Table 32.

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

OPERATIONAL ALGORITHM DESCRIPTION DOCUMENT FOR OMPS TOTAL COLUMN (TC) SDR

SDRL No. S141
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 DESCRIPTION DOCUMENT FOR OMPS TOTAL COLUMN (TC) SDR

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

CAGE NO. 11982

Operational Algorithm Description
OMPS Total Column SDR

Document Number: D39310
Document Date: Nov 06, 2011 **Revision: D5**

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

Northrop Grumman Space & Mission Systems Corp. **Space Technology** One Space Park Redondo Beach, CA 90278	NORTHROP GRUMMAN Raytheon
Revision/Change Record	**Document Number D39310**

Revision	Document Date	Revision/Change Description	Pages Affected
---	9-3-04	Initial Release.	All
A	1-21-05	Revision mandated by SPCR ALG00000595 for an official delivery to IDPS.	All
B1	3-16-05	Reflects Science To Operational Code Conversion.	All
B2	3-17-05	Added discussion for SCD to SDPTLK data conversion.	All
B3	7-18-08	Redlined version from NGST. Implemented tech memos NP-EMD.2007.510.0063-Rev-A and then NP-EMD.2008.510.0042.	All
B4	1-30-09	Reformat to new OAD template. Updated for CCPR. Fixed CCPR action items. Prepared for SDRL Delivery.	All
B	5-13-09	Prepared for TIM/ARB/ACCB.	All
C1	07-09-09	Updates based on Technical Memorandum NP-EMD_2009_510_0002_OMPS_TC_SDR_OAD_RevE and sensor characterization 4.2.1. SDRL delivery.	All
C2	8-19-09	Updated based on post-SDRL comments.	13, 23, 50
C3	9-2-09	Updated based on software changes made in PCR020445 and PCR020829	25, 26
C4	12-18-09	Updated due to NP-EMD.2009.510.0054_NPP_OMPS_TC_SDR_errorterms.docx	All
C5	5-24-10	Updated due to ECR-1053A and ECR-1054B, includes PCR023161 and PCR023367.	All
C	7-07-10	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, 2010.510.0014 & 2010.510.0016	All
D3	10-22-10	Updated due to ECR-A317B and tech memo 2010.510.0041.	All
D4	06-29-11	Updated for ECR-A0016 and TM 2011.510.0007	All
D5	11-06-11	Updated for PCRs PCR026493, PCR026710, PCR026938, PCR027342 & PCR027485	All

Table of Contents

List of Figures

List of Tables

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. This particular document describes operational software implementation for the Ozone Mapping and Profiler Suite (OMPS) Total Column (TC) Sensor Data Records (SDR).

1.2 Scope

The scope of this document is limited to the description of the core operational algorithm(s) required to create the OMPS TC SDR. The theoretical basis for this algorithm is described in Section 3.1.3 of the OMPS NADIR Total Column Ozone Algorithm Theoretical Basis Document ATBD, 474-00029.

1.3 References

1.3.1 Document References

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

Table 1: Reference Documents

Document Title	Document Number/Revision	Revision Date
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

Document Title	Document Number/Revision	Revision Date
OMPS Command and Telemetry Handbook	V6.6	12 Oct 2004
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) Nadir Profile (NP) Sensor Data Record (SDR)	474-00081	Latest
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 (PR) 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	Latest

Document Title	Document Number/Revision	Revision Date
	Vol VIII	
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
NP-EMD.2005.510.0124_ TC_3.1.1_OAD_updates_memo_v4	NP-EMD.2005.510.0124	23 May 2005
NP-EMD.2007.510.0063.RevA_ OMPS_TC_SDR_OAD_update_RevA	NP-EMD.2007.510.0063.RevA	09 Nov 2007
NGST/DPSE Tech Memo Total Column SDR Delivery 4.2: updates required for previous OADs	NP-EMD.2008.510.0042	18 Jul 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 Total Column SDR delta delivery v4.2.1: OAD updates	NP-EMD.2009.510.0002	21 Jan 2009
Sensor Characterization Database Interface Control Document (SCD ICD)	2255337 Rev C	23 Mar 2007
NGAS/A&DP Tech Memo NPP_OMPS_TC_SDR_errorterms	NP-EMD.2009.510.0054	09 Oct 2009
NGST/SE technical memos: PC_OAD_Last_Drop_Corrections PC_Format_Corrections SAD_Format and Usage_Corrections	 NPOESS GJM-2010.510.0013 NPOESS GJM-2010.510.0014 NPOESS GJM-2010.510.0016	 22 Sep 2010 22 Sep 2010 22 Sep 2010
NGST/A&DP Tech Memo OMPS_inst2sc.pdfs	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

Reference Title	Reference Tag/Revision	Revision Date
OMPS Unit Test Data D39312	RevD	21 Jan 2009
ClearCase Configuration Controlled Source Code	Version 5.1	31 Mar 2003
ClearCase Configuration Controlled Source Code	ISTN_OMPS_TC_NGST_2.3	03 Sep 2004
ClearCase Configuration Controlled Source Code	ISTN_OMPS_TC_NGST_3.1	21 Jan 2005
ClearCase Configuration Controlled Source Code	ISTN_OMPS_TC_NGST_3.1.1	16 Dec 2005
ClearCase Configuration Controlled Source Code	ISTN_OMPS_TC_NGST_4.1	13 Feb 2008

Reference Title	Reference Tag/Revision	Revision Date
NGST/DPSE Tech Memo Total Column SDR Delivery 4.1: updates required for previous OADs	NP-EMD.2007.510.0063-Rev-A (OAD Rev B3)	09 Nov 2007
ClearCase Configuration Controlled Source Code	ISTN_OMPS_TC_NGST_4.2	09 Sep 2008
NGST/DPSE Tech Memo Total Column SDR Delivery 4.2: updates required for previous OADs	NP-EMD.2008.510.0042 (OAD Rev B3)	18 Jul 2008
ClearCase Configuration Controlled Source Code	ISTN_OMPS_TC_NGST_4.2 Rev A	11 Dec 2008
ClearCase Configuration Controlled Source Code	ISTN_OMPS_TC_NGST_4.2.1	01 Jan 2009
OMPS TC SDR Operational software	I1.5.00.35 (OAD Rev B4)	01 Jan 2009
NGAS/A&DP Tech Memo OMPS Total Column SDR delta delivery v4.2.1: OAD updates	NP-EMD.2009.510.0002 (OAD Rev C1)	21 Jan 2009
ClearCase Configuration Controlled Source Code	ISTN_OMPS_TC_NGST_4.2.2	10 Jun 2009
OMPS TC SDR Operational software	Sensor Char build SC-4 (OAD Rev C3)	10 Oct 2009
OMPS TC SDR Operational software NP-EMD.2009.510.0054	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_TC_NGST_4.2.4	26 May 2010
ACCB	OAD Rev C	07 Jul 2010
PCR023947 (ECR-A306)	Sensor Char build SC-12 (OAD Rev D1)	16 Jul 2010
ClearCase Configuration Controlled Source Code	ISTN_OMPS_TC_NGST_4.2.5 _Data (ECR 317)	20 Sep 2010
Convergence Updates (No code updates)	(OAD Rev D2)	20 Oct 2010
OMPS TC 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	Build MX.1.5.6.00 (OAD Rev-D5)	06 Nov 2011

Reference Title	Reference Tag/Revision	Revision Date
update only)		
OAD transitioned to JPSS Program – this table is no longer updated.		

2.0 ALGORITHM OVERVIEW

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

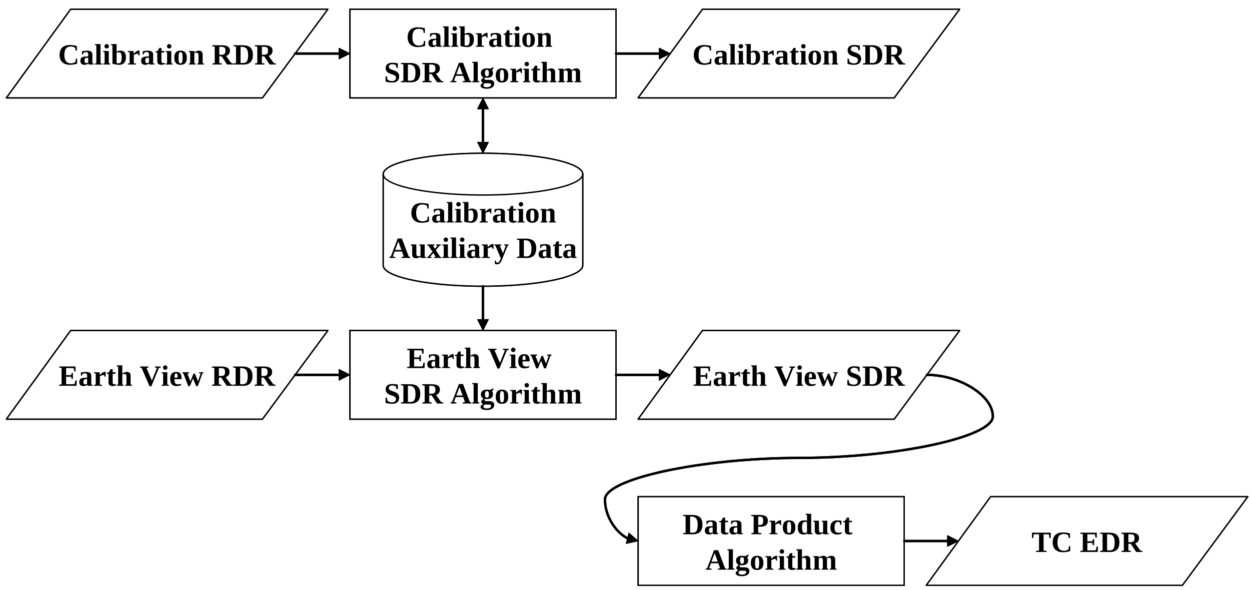

Figure 1: Processing Chain Associated with the OMPS TC Ozone

2.1 Total Column Ozone Sensor Data Record Description

The OMPS Total Column 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 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 TC 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 interfaces to these SIs are implemented by FORTRAN libraries and 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.

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 TC SDR algorithm and are linked to the TC SDR algorithm as a library.

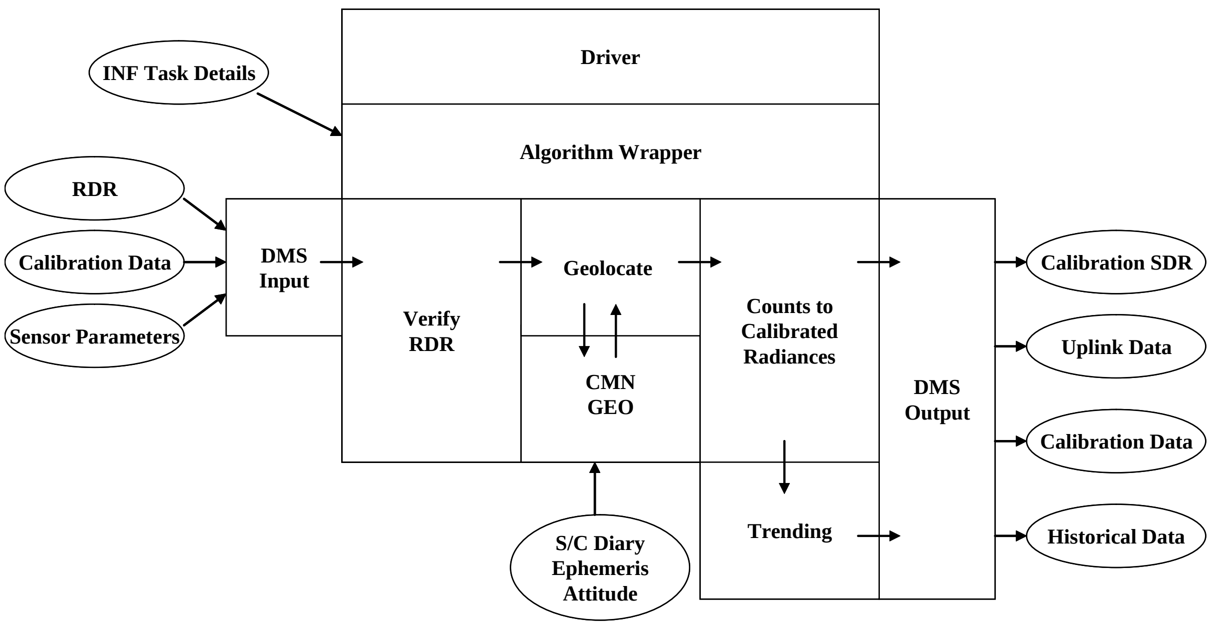

Figure 2: Calibration SDR Processing Schematic

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.

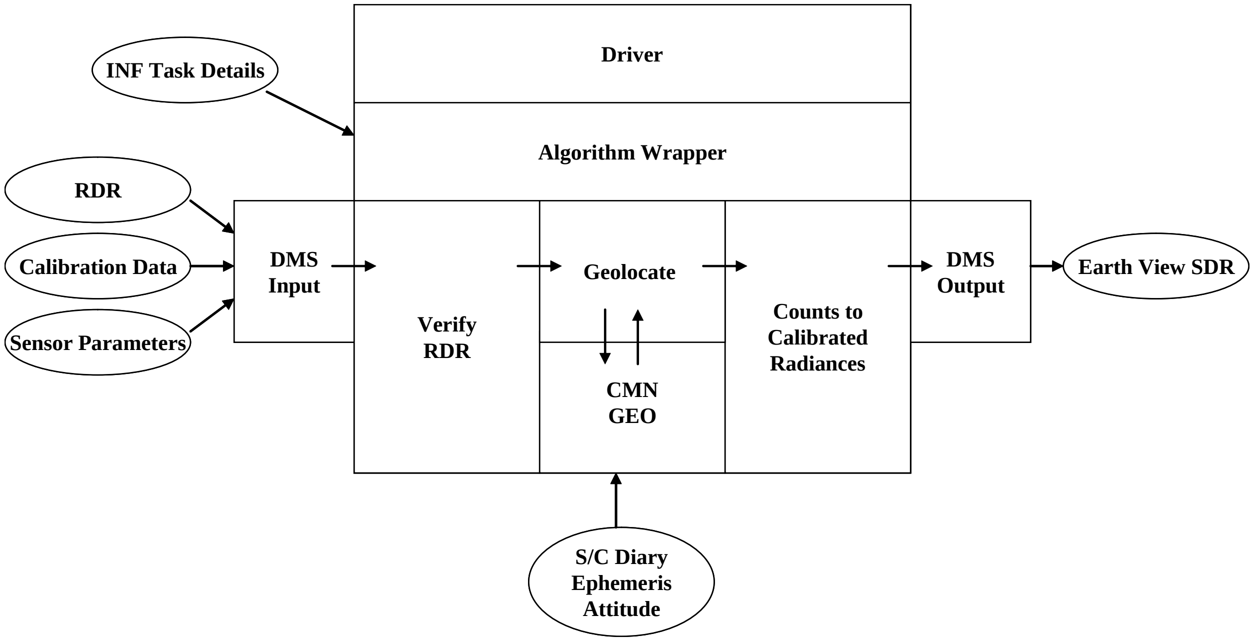

Figure 3: Earth View SDR Processing Schematic

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 as described in Table 3 through Table 30. Each input is listed as a separate table in this section. In Tables 22-28, "Ground ISF" refers to Ground Integrated Support Facility.

Table 3: OMPS Total Column SDR Input: Biases

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
bias1	Float32	Electronics bias value for 1st CCD image half	counts / 0 - 1.00E+05
bias2	Float32	Electronics bias value for 2nd CCD image half	counts / 0 - 1.00E+05

Table 4: OMPS Total Column SDR Input: BRDF Grids

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
minAzim	Float32 * 7	Minimum solar azimuth	Degrees / None - None

Input	Type	Description	Units/Valid Range
maxAzim	Float32 * 7	Maximum solar azimuth	Degrees / None - None
minElev	Float32 * 7	Minimum solar elevation	Degrees / None - None
maxElev	Float32 * 7	Maximum solar elevation	Degrees / None - None
gspat_offset	Int32 * 7	starting spatial index for non-fill calibrated data in full CCD coordinates	Unitless / None - None
gspec_offset	Int32 * 7	starting spectral index for non-fill calibrated data in full CCD coordinates	Unitless / None - None
gspat_size	Int32 * 7	extent of spatial indices for calibrated data	Unitless / None - None
gspec_size	Int32 * 7	extent of spectral indices for calibrated data	Unitless / None - None
gazim_size	Int32 * 7	number of azimuth angles	Unitless / None - None
gelev_size	Int32 * 7	number of elevation angles	Unitless / None - None
Pixel-Level Data Items			
BRDF_grid	Float32 * 7 * 198 * 200 * 40 * 40	Bi-directional Reflectance Directional Function (one for each of the 7 diffuser positions)	Unitless / None - None

Table 5: OMPS Total Column SDR Input: Calibration Constants

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
radevresp	Float32 * 2 * 364 * 780	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 Total Column 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 trending	years / 2000 - 2050
monitor_day	Int32 * 29	Last day of data used for trending	days / 1 - 366
Pixel-Level Data Items			
extrap_cfsolar	Float32 * 29 * 364 * 740	Radiometric calibration factors	unitless / 0 - None

Table 7: OMPS Total Column SDR Input: Darks

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
good_darks	Int32	Number of quality checked	Unitless / Minimum - Maximum
Scan-Level Data Items			
expose_dark	Float64	Exposure time	seconds / 0 - None
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	seconds / 0 - None
qual_dark	Int16 * 5	Quality of processing	Unitless / None - None
istat_dark	Int16 * 5	Instrument status	Unitless / Minimum - Maximum
analog_dark	Float32 * 5	Instrument/data record status	Unitless / Minimum - Maximum
saa_dark	Float32 * 5	Average SAA severity at begin and end of observation	percent / 0 - 100
Pixel-Level Data Items			
dark_data	Float32 * 364 * 740	Corrected dark current counts	counts / None - None

Table 8: OMPS Total Column SDR Input: SAA Darks

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
darksaa_frames	Int32	Number of good dark frames that made up the average dark data	Unitless / Minimum - Maximum
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	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 * 5 * 364 * 740	Corrected dark current counts	counts / None - None

Table 9: OMPS Total Column SDR Input: Field Angles Map

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
angles	Float64 * 780 * 2	Pre-launch angles map 1. cross-track view angles 2. along-track view angles	radians / -1 - 8.6044729E-02

Table 10: OMPS Total Column SDR Input: Flat Field History

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
obs_year	Int32 * 29	Year of flat field record	years / 2000 - 2050
obs_day	Int32 * 29	Day of flat field record	days / 1 - 366
old_nmonitor	Int32 * 29	Number of calibration times used for trending flat field	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
flat	Float32 * 29 * 364 * 740	Flat field: local relative normalized radiometric sensitivities	unitless / none - none

Table 11: OMPS Total Column 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	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	Unitless / 1 - 28
rsf_avg_scan_time	Float64	Average exposure time of reference solar flux	seconds / 0 - None
no_observations	Int32	Number of observations	Unitless / Minimum - Maximum
rsf_expose	Float64	Total exposure time of reference solar flux	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
avg_solar_beta	Float32 * 10	Angle between current orbital plane and sun	degrees / -180 - 180
no_work_frames	Int32 * 10	Number of solar data observations constituting	Unitless / 0 - None
avg_sol_scan_time	Float64 * 10	Average exposure time of raw flux solar data	seconds / 0 - None
total_sol_expose	Float64 * 10	Total exposure time of raw flux solar data	seconds / 0 - None
Pixel-Level Data Items			
rsf_data	Float32 * 364 * 780	Reference solar flux	W/cm^3 / 0 - 1800

Input	Type	Description	Units/Valid Range
rsf_counts	Float32 * 364 * 780	Reference solar counts	counts / None - None
shift_flux	Float32 * 10 * 364 * 740	The current solar flux, ratioed by the baseline solar flux, both at the baseline wavelengths	Unitless / None - None

Table 12: OMPS Total Column 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
nshifts	Int16	number of shifts	Unitless / 167 - 167
Scan-Level Data Items			
instrument	Int8 * 12	Instrument name	Unitless / Total Column - Total Column
indexes	Int16 * 10	line pixel number	pixels / 5 - 163
wlines	Float64 * 10	selected wavelength lines for monitoring	nanometers / 302 - 369
refshifts	Float64 * 10 * 167	selected wavelength shifts for monitoring	nanometers / None - None
irrad_diff	Float64 * 10 * 167	selected irradiance shifts for monitoring	Unitless / None - None
wref_l	Float64 * 364	reference wavelengths	nanometers / 300 - 380

Table 13: OMPS Total Column SDR Input: Observed Solar

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
rsf_data	Float32 * 364 * 780	Baseline OMPS observed reference solar irradiances	W/cm^3/sterad / 0 - ~1316
rsf_counts	Float32 * 364 * 780	Baseline OMPS observed reference solar counts	counts / 24531.2 - 16708400

Table 14: OMPS Total Column SDR Input: Predicted Solar

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
womps	Float64 * 2040	Solar wavelengths predicted from spectral functions	Nanometers / 298 - 380
fomps	Float64 * 2040	Solar irradiances predicted from spectral functions	W/cm^3/sterad / 400 - 1504

Table 15: OMPS Total Column 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	Angle between orbital plane and sun vector	unitless / 1 - 2
rsf_number_coadds	Int32	Number of solar observations constituting	unitless / 1 - 28
rsf_avg_scan_time	Float64	Average exposure time of reference solar flux	seconds / 0 - none
rsf_expose	Float64	Total exposure time of reference solar flux	seconds / 0 - none
latest_year	Int32	Year of current solar data	years / 2000 - 2050
latest_day	Int32	Day of current solar data	days / 1 - 366
avg_solar_beta	Float32	Average of solar beta	degrees / -180 - 180
n	Int32	Working diffuser surface (nominal value is 1)	unitless / 1 - 1
m	Int32	Number of solar data	unitless / 0 - none
avg_sol_scan_time	Float64	Average exposure time of raw	seconds / 0 - none
t_expose	Float64	Total exposure time of raw flux	seconds / 0 - none
Scan-Level Data Items			
rsf_data	Float32 * 364 * 780	Reference solar flux	w_cm_pow3 / 0 - 1800
rsf_counts	Float32 * 364 * 780	Reference solar counts	counts / none - none
rawflx_data	Float32 * 364 * 740	Ratio of current observed solar counts to reference solar counts	unitless / none - none

Table 16: OMPS Total Column SDR Input: Solar Irradiance

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
wsun	Float64 * 2040	Solar wavelengths of calibration standard	Nanometers / 289 - 390
fsun	Float64 * 2040	Solar irradiances of calibration standard	W/cm^3/sterad / 307 - 1585

Table 17: OMPS Total Column SDR Input: Solar Irradiance Calibration Constants

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
iradsolresp	Float32 * 2 * 7 * 364 * 780	Solar irradiance calibration coefficients	counts/W/cm^3/sterad) / 2.89661 - 3299.13

Table 18: OMPS Total Column SDR Input: Spectral Response Function

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
wave_prof	Float64 * 24	Wavelengths	nanometers / 290 - 390
offsetw	Float64 * 994	Offset wavelengths	nanometers / -2.6 - 2.6
wavefunc	Float64 * 994 * 24	Spectral responses	Unitless / 0 - 1

Table 19: OMPS Total Column SDR Input: Spectral Registration Pixel Map

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
wmap	Float64 * 364 * 780	Pre-launch wavelengths map	nanometers / 290 - 390

Table 20: OMPS Total Column SDR Input: Wave Fitting Parameters

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
iterate	Int32	processing switch	Unitless / F - T
write_fit	Int32	processing switch	Unitless / F - T
weight	Int32	processing switch	Unitless / F - T
mirror	Int32	processing switch	Unitless / F - T
autodiff	Int32	processing switch	Unitless / F - T
wavelo	Float64	wavelength lower limit for fitting	nanometers / 303.5 - 376.5
wavehi	Float64	wavelength upper limit for fitting	nanometers / 303.5 - 376.5
delchi	Float64	convergence criteria	Unitless / 1.00E-12 - 1.00E-12
provar	Float64	convergence criteria	Unitless / 1.00E-12 - 1.00E-12
Scan-Level Data Items			
inputLine	Int8 * 72	describes product content	Unitless / Text
var	Float64 * 64	polynomial parameters	Unitless / 1.00E-12 - 1.00E-12
if_varied	Int32 * 64	vary parameter	Unitless / F - T
diff	Float64 * 64	increment parameter	Unitless / F - T
lock	Int32 * 64	unused lock	Unitless / 0 - 0
alock	Float64 * 64	unused lock	Unitless / 0 - 0
block	Float64 * 64	unused lock	Unitless / 0 - 0

Table 21: OMPS Total Column SDR Input: Wave Monitor

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
wmin	Float32	Wavelength minimum	nanometers / 290 to 390
wmax	Float32	Wavelength maximum	nanometers / 290 to 390
nlines	Int16	Number of monitor lines	unitless / 1 to 10
offset_pix	Int16	Offset pixel monitored	pixels / 1 to 3
no_observations	Int32	Num of observations for trending	unitless / 0 to 10
Scan-Level Data Items			
refname	UInt8 * 30	Solar Spectrum Filename	unitless / N/A – N/A
tablename	UInt8 * 36	Line-Shift Table Filename	unitless / N/A – N/A
line_locates	Int16 * 10	Line Pixel Numbers	pixels / 1 - 192
waveline	Float32 * 10	Line Monitor Wavelengths	nanometers / 290 - 390
year	Int32 * 10	Year of current solar data	years / 2000 - 2050
day	Int32 * 10	Day of current solar data	days / 1 - 366
avg_solar_beta	Float32 * 10	Solar Mean Beta-Angle	degrees / -180 - 180
diffuser	Int16 * 10	Diffuser surface	unitless / 1 - 2
nadd	Int32 * 10	Number of Solar observations used	unitless / 1 - 10
resolution	Float64 * 10	FWHM wavelength resolution	nanometers / 0 - None
r_delw_c	Float64 * 10 * 105	Waveshift	nanometers / none - none
r_scale_c	Float64 * 10 * 105	Wavestretch	unitless / none - none
r_rchisq_c	Float64 * 10 * 105	Reduced Chi^2	unitless / 0 - none
r_delw_line	Float64 * 10 * 105	Group lineshift	nanometers / none - none
r_add_l	Float64 * 10 * 105	fit lineshift	nanometers / none - none
r_stretch_l	Float64 * 10 * 105	fit slope	unitless / none - none
r_correl_l	Float64 * 10 * 105	Correlation	unitless / -1 - 1
shift	Float32 * 10 * 10 * 105	Individual lineshifts	nanometers / none - none

Table 22: OMPS Total Column SDR Input: Ground ISF Approved Wavelengths

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
obs_year	Int16 * 29	Year	years / 2000 - 2050

Input	Type	Description	Units/Valid Range
obs_day	Int16 * 29	Day	days / 1 - 366
resolution	Float64 * 29	FWHM wavelength resolution	nanometers / 0 - None
ntrends	Int32 * 29	number of calibrations used for trend	Unitless / 3 - None
newestyear	Int16 * 29	Year of newest calibration trended	years / 2000 - 2050
newestday	Int16 * 29	Day of newest calibration trended	days / 1 - Maximum
intercept	Float64 * 29 * 105	Intercept line	nanometers / None - None
slope	Float64 * 29 * 105	Slope line	Unitless / None - None
correl	Float64 * 29 * 105	Correlation	Unitless / 0 - None
wbands	Float64 * 29 * 364 * 105	Wavelengths	nanometers / 290 - 390

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 (sample table and bad pixel) database. See Table 23.

Table 23: OMPS Total Column SDR Input: Ground ISF Approved Earth View Sample Table

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
badpixBATC	Int32 * 364 * 780	Flight-like earth view sample table of pixels	Enumerated / 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 (sample table and bad pixel) database. See Table 24.

Table 24: OMPS Total Column SDR Input: Ground ISF Approved LED Sample Table

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
lampsample	Int32 * 364 * 780	linearity LED sample table array	none / 0 - 2 0 = unused pixel 1 = macropixel A 2 = macropixel B

Solar Calibration Sample Table

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

Table 25: OMPS Total Column SDR Input: Ground ISF Approved Solar Calibration Sample Table

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
macrot	Int32 * 7 * 364 * 780	Sample table array for each of 7 solar diffuser positions	none / 0 - 2 0 = unused pixel 1 = macropixel A 2 = macropixel B

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 (sample table and bad pixel) database. See Table 26.

Table 26: OMPS Total Column SDR Input: Ground ISF Approved Macropixel Table

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
macrot	Int32 * 364 * 780	Macropixel table array Negative number indicates all bad macropixel	none / -N - N

Linearity Table

Linearity table is a linearity lookup table. The linearity lookup 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 are four sets: primary and redundant electronics and both CCDs. The data is derived from BATC's LED (Linearity and LED signal) database. See Table 27.

Table 27: OMPS Total Column SDR Input: Ground ISF Approved Linearity Table

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
linearity_table	Float32 * 2 * 2 * 16384	linearity conversion LUT primary CCD1 primary CCD2 redundant CCD1 redundant CCD2	unitless / 1 – 100,000

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 (Linearity and LED Signal) database. See Table 28.

Table 28: OMPS Total Column 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	none / 1 - 1
TPsol_num	Int32	Number of Solar frames	none / 1 - 1
TPdark_num	Int32	Number of Dark frames	none / 1 - 1
TPled_num	Int32	Number of Lamp frames	none / 1 - 1
TPev_conum	Int32	Number of Earth View coadds	none / 1 - 1
TPsol_conum	Int32	Number of Solar coadds	none / 1 - 7
TPdark_conum	Int32	Number of Dark coadds	none / 1 - 1
TPled_conum	Int32	Number of Lamp coadds	none / 1 - 83
ev_time_offset	Int64	Delta time for Earth View time correction	microseconds / 0 - Max
sol_time_offset	Int64	Delta time for Solar time correction	microseconds / 0 - Max
dark_time_offset	Int64	Delta time for Dark correction	microseconds / 0 - Maxi
led_time_offset	Int64 * 150	Delta times for Lamp correction	microseconds / 0 - Max
Scan-Level Data Items			
TPev_time	Float32 * 15	Total integration time for each frame	seconds / 1 - none
TPsol_time	Float32 * 63	Total integration time for each frame	seconds / 1 - none
TPdark_time	Float32 * 5	Total integration time for each frame	seconds / 1 - none
TPled_time	Float32 * 150	Total integration time for each frame	seconds / 1 - none

Table 29: OMPS Total Column SDR Input: Calibration Coefficients

Input	Type/Size	Description
deviate	Float64	Correlation threshold for identifying deviations
qUp1PrimaryElec	Float64	Upper tie point for primary electronics on CCD1
qUp2PrimaryElec	Float64	Upper tie point for primary electronics on CCD2
qUp1RedundantElec	Float64	Upper tie point for redundant electronics on CCD1
qUp2RedundantElec	Float64	Upper tie point for redundant electronics on CCD2
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
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.
motorRate	Float32	Motor rate coefficient
tcFov	Float32	Cross-track full FOV angular width.
diffusersOffset	Float32	Angle between reference diffuser stowed position and mid position.
diffuserSep	Float32	Separation angle between nominal diffuser positions.
biasDefault	Float32	Default electronics bias value in counts.
radHigh	Float32	Maximum expected radiance.
badSaa	Float32	Threshold SAA value for bad flag
fullWidth	Float32	Expected nominal spectral FWHM (full width at half maximum)
solarSize	Float32	Sun disk diameter
diffEdgeAngle	Float32	Tolerance angle from diffuser edge in degrees
nwaveTrends	Int32	Number of solar calibrations to trend wavelengths
wmonInterval	Int32	Number of days between wavelength monitoring observations
trendCf	Int32	Number of solar calibrations to trend radiances.
cfInterval	Int32	Number of days between each CF Solar and CF Earth period
bias_indx	Int32 * 4	Specifies the lower and upper bounds of the serial overclock pixels to be used in bias estimate
nalts	Int32	Deprecated
altitudeBinM	Int32	Deprecated
lpSeparation	Int32	Deprecated
lpNoTrack	Int32	Deprecated
nsamp	Int32	Deprecated
nfunc	Int32	Deprecated
norder	Int32	Deprecated
diffEndEdges	Int32 * 8	Tells you where to stitch the Diffuser Ends together to form a single output
trendGapMax	Int32	Tells you how many days are tolerated between cal events before you cannot do trending

Input	Type/Size	Description
badPixLowerThreshold	Int32	The lower threshold for bad pixels. Values below this number are considered bad. Note: In the science code this variable is BadPixThreshold1
badPixUpperThreshold	Int32	The upper threshold for bad pixels. Values above this number are considered bad. Note: In the science code this variable is BadPixThreshold2
goniometryOn	bool	Switch for processing goniometry during execution.
cfSolarCorrect	Bool	Determines if the CF solar correction should be performed
isSlCor	Bool	Determines if the stray light correction should be performed

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 in this section as well as other referenced tables. 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 Total Column SDR Input: Biases. This input is in the same format as the Biases input.

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

Table 31: OMPS Total Column 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 * 105	Radiometric calibration factors	Unitless / 0 - None

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

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

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

See Table 13: OMPS Total Column SDR Input: Observed Solar. This input is in the same format as the Observed Solar input.

See Table 14: OMPS Total Column SDR Input: Predicted Solar. This input is in the same format as the Predicted Solar input.

See Table 17: OMPS Total Column SDR Input: Solar Irradiance . This input is in the same format as the Solar Irradiance LUT input.

See Table 18: OMPS Total Column SDR Input: Spectral Response Function. This input is in the same format as the Spectral Response Function input.

See Table 19: OMPS Total Column SDR Input: Spectral Registration Pixel Map. This input is in the same format as the Spectral Registration Pixel Map input.

See Table 22: OMPS Total Column SDR Input: Ground ISF Approved Wavelengths. This input is in the same format as the Ground ISF Approved Wavelengths input.

See Table 23: OMPS Total Column 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 input.

See Table 26: OMPS Total Column SDR Input: Ground ISF Approved Macropixel Table. This input is in the same format as the Ground ISF Approved Macropixel Table input.

See Table 27: OMPS Total Column SDR Input: Ground ISF Approved Linearity Table. This input is in the same format as the Ground ISF Approved Linearity Table input.

See Table 28: OMPS Total Column 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 29: OMPS Total Column SDR Input: Calibration Coefficients. This input is in the same format as the Calibration Coefficients input.

Table 32: OMPS Total Column 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 * 20	Index of block boundaries-inclusive	Unitless / 1 - nchan
indx_oor	Int32 * 4	Index super channels	Unitless / 1 - nchan
c370	Float32	Predictor	Unitless / 1 – nchan
c360	Float32	Predictor	Unitless / 1 – nchan
c_power	Float32	Predictor	Unitless / 1 – nchan
sl_cor_oor	Float32 * 105 * 260 * 105	OOR stray light coefficients	Unitless / reals
sl_cor_coef	Float32 * 20 * 105 * 260*105	Stray light correction coefficients	Unitless / reals

2.1.1.1.3 RDR Input

The MDFCB contains the RDR input parameters assumed by the SDR algorithm for the Total Column Earth View RDR (APID 560) and calibration RDR (APID 564).. 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.

All RDR parameters are ingested by one of two program modules: RDF_input_cal.f or RDF_input_earth.f. These subroutines input the RDR Command & Telemetry header data and either the raw calibration or Earth view CCD data.

Appendix A describes the coordinate systems used by the Algorithm. The exact size of the data arrays are not known for each RDR a priori and are found using a series of sample tables. Factors such as the spectral smile changes with time and the exact pixels used by the Algorithm therefore also changes with time. These changes are reflected in the sample tables. Please refer to Appendix A for a complete description of the coordinate systems as they are used throughout the text. Most arrays are initialized to be the size of the full CCD, 780 x 364 (hereafter the Full Array), and then a working array size is defined based on the RDR data. When a parameter is described in the tables in this document, the array size given is the working array size.

2.1.1.1.4 Control/Initialization Inputs

2.1.1.1.4.1 Control Parameters

Wavelength Fitting Parameters

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 four parameters)
(b) #5-8 a cubic polynomial in overall radiometric scaling (the second group of four 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 TC ATBD, 474-00029 (Sections 3.1.3.3 and 3.1.3.4.10).

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 this would normally be
# false.  Sometimes I select out of a wider spectrum and weight
# accordingly.

# 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
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 TC nadir view along the ground track consists of a set of angles relative to the nadir. To geolocate the TC data, the algorithm uses a map of these field angles derived from pre-launch view characterizations. To fully geolocate the TC 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 BATC's SRG (spatial registration) database. See Table 9 for format details.

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 tables). These observations are considered in a Flattery analysis and are used to create regularly intervalled grids. 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. The goniometry coefficients are derived from BATC's GON (goniometry) database. There is a sun-earth distance correction applied based on day of the year. 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. Calibration Constants LUT contains the radiance calibration coefficients and is used with the variable resp_piece to calculate the cal variable in the tc_earth_view subroutine. This data is derived from BATC's RAD (radiance calibration coefficients) database. Solar Irradiance Calibration Constants LUT contains the irradiance calibration coefficients that are used in the Combine_solar subroutine. This data is derived from BATC's IRD (irradiance calibration coefficients) database. Both LUTs have values for every pixel in the Full Array, but only the CVO portion is used. The third dimension of the data represents the two sets of electronics: 1 = primary electronics, 2 = secondary electronics. The data in Solar Irradiance Calibration Constants LUT has valid values filled according to the illuminated area for each solar diffuser position. See Table 5 and Table 17 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 TC sensor. This map describes the pre-launch wavelength band centers for all illuminated pixels on the CCDs. These bandcenters correspond to the centroids of the spectral response functions discussed above. Whether calibrated on the ground or derived from baseline solar measurements, the bandcenters and response functions together define the baseline sensor spectral registration. This data is derived from BATC's (channel bandcenters) database. See Table 19 for format details.

Spectral Response Functions

The algorithm uses a set of spectral response functions to determine the current wavelengths detected by the TC 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 TC 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 (bandpass) database. 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. For Line Shift Table format details, see Table 12.

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 23: OMPS Total Column SDR Input: Ground ISF Approved Earth View Sample Table
2. Table 26: OMPS Total Column SDR Input: Ground ISF Approved Macropixel Table
3. Table 25: OMPS Total Column SDR Input: Ground ISF Approved Solar Calibration Sample Table
4. Table 24: OMPS Total Column SDR Input: Ground ISF Approved LED Sample Table
5. Table 28: OMPS Total Column SDR Input: Ground ISF Approved Timing Pattern Table
6. Table 27: OMPS Total Column 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.

2.1.1.1.4.3 Initialization Parameters

Standard High-Resolution Solar Irradiance and its low resolution analogs

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. See Table 16, Table 14, and Table 13 for formats.

Note that this reference solar data is for test. For operations, the baseline irradiances and counts must be taken from actual flight measurements of the sun as early in the mission as possible, using the ground laboratory pre-launch rad_to_counts and wavelengths to calibrate the reference solar flux but only after the in-flight dark current, smear, and biases have been subtracted from the solar counts.

2.1.1.2 Outputs

A description of the SDR outputs begins in Section 3.1.1.2 of the TC ATBD, 474-00029. Earth view SDRs are discussed in Section 3.1.1.2.1, Calibration SDRs in Section 3.1.1.2.2, calibration databases in Section 3.1.1.2.3 and uplink files in Section 3.1.1.2.4.

2.1.1.2.1 Calibration SDR Outputs

Each Calibration output is listed in tables 32 through 36 in this section 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 ealier section of this document, a reference is made back to the table in which the output was first described.

See Table 15: OMPS Total Column SDR Input: Raw Flux. The output is in the same format as the Raw Flux input.

Table 33: OMPS Total Column SDR Output: Lamp Auxiliary

Input	Type/Size	Description	Units/Valid Range
Granule-Level Data Items			
no_lamp_frames	Int32	Number of lamp frames	unitless / 2 - 50
recid_lamp	Int32 * 150	Record identification number	unitless / 0 - none
lseq_lamp	Int32 * 150	Logical sequence number	unitless / 0 - none
iyear_lamp	Int32 * 150	Year of observation	years / 2000 - 2050
iday_lamp	Int32 * 150	Day of observation	days / 1 - 366
time_start_lamp	Float64 * 150	Time start of observation	seconds / 0 - none
time_end_lamp	Float64 * 150	Time end of observation	seconds / 0 - none
delta_time_lamp	Float64 * 150	Exposure time	seconds / 0 - none
qual_lamp	Int16 * 150	Quality of processing	unitless / Minimum - Maximum
istat_lamp	Int16 * 150	Instrument status	unitless / Minimum - Maximum
analog_lamp	Float32 * 150	Instrument/data record status	unitless / Minimum - Maximum
saa_lamp	Float32 * 150	South Atlantic Anomaly severity flag	percent / 0 - 100
lamp_data	Float32 * 150 * 364 * 780	Lamp current counts	counts / none - none

See Table 10: OMPS Total Column SDR Input: Flat Field History. This output is the same format as the Flat Field input.

See Table 11: OMPS Total Column SDR Input: Flux. This output is the same format as the Flux input.

See Table 7: OMPS Total Column SDR Input: Darks. This output is the same format as the Darks input.

See Table 8: OMPS Total Column SDR Input: SAA Darks. This output is the same format as the SAA Darks input.

See Table 31: OMPS Total Column 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 Total Column SDR Input: Calibration Factors - Solar. This output is the same format as the Calibration Factors – Solar input.

See Table 3: OMPS Total Column SDR Input: Biases. This output is the same format as the Biases input.

Table 34: OMPS Total Column SDR Output: Bad Pixels Auxiliary

Input	Type/Size	Description	Units/Valid Range
Pixel-Level Data Items			
bad_pixels	Int32 * 364 * 740	Pixels flagged bad if dark data for that pixel exceeds thresholds. 0 = bad 1 = good	unitless / 0 - 1
dark_data	Float32 * 364 * 740	Corrected dark current counts	counts / None - None

See Table 21: OMPS Total Column SDR Input: Wave Monitor

Table 35: OMPS Total Column SDR Output: Flat Fields Proposed Upload

Input	Type/Size	Description	Units/Valid Range
Pixel-Level Data Items			
flat	Float32 * 364 * 740	local relative normalized pixel radiometric sensitivities	unitless / 0.5 - 1.5

See Table 22: OMPS Total Column SDR Input: Ground ISF Approved Wavelengths. Calibration produces a Wavelengths auxiliary that is in the same format as the Ground ISF Approved Wavelengths.

See Table 27: OMPS Total Column SDR Input: Ground ISF Approved Linearity Table. Calibration produces a Linearity Proposed Upload Auxiliary that is in the same format as the Ground ISF Approved Linearity Table.

Table 36: OMPS Total Column SDR Output: Linearity Auxiliary

Input	Type/Size	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 - None
nramp	Int32	Number of ramp lamp observations	unitless / 2- 150
nref	Int32	Number of ref lamp observations	unitless / 2- 150
slope	Float64*2	Reference lamp integration time	seconds / 0 - None
Scan-Level Data Items			
iyear_lamp	Int32 * 150	Year of lamp observation	years / 2000 - 2050
iday_lamp	Int32 * 150	Day of lamp observation	days / 1 - 366
lamp_integration	Float32 * 150	Individual exposure time of each lamp image	seconds / 0 - None
lamp_uc_ramp	Float32 * 150 * 2	Weighted integration times	unitless / None - None
Qideal	Float64 * 150 * 2	Corrected dark current counts	counts / None - None

Table 37: OMPS Total Column SDR Output: Calibration Geolocation

Input	Type/Size	Description	Units/Valid Range
Granule-Level Data Items			
numSolar	Int16	Actual number of solar frames (images)	Unitless / 0 - 63
numDark	Int16	Actual number of dark frames (images)	Unitless / 0 - 5
numLamp	Int16	Actual number of lamp frames (images)	Unitless / 0 - 150
Scan-Level Data Items			
startTimeSolar	Int64 * 63	Start time of solar frame in IET (1/1/1958)	microseconds / 0 - None
midTimeSolar	Int64 * 63	Mid-Time of solar frame in IET (1/1/1958)	microseconds / 0 - None
endTimeSolar	Int64 * 63	End time of solar frame in IET (1/1/1958)	microseconds / 0 - None
moonVectorSolar	Float32 * 63 * 3	Lunar Position in Spacecraft Coordinates at MidTime_Solar	meters / 0 - None
sunVectorSolar	Float32 * 63 * 3	Solar position in Spacecraft Coordinate System at MidTime_Solar	meters / 0 - None
spaceCraftPosition Solar	Float32 * 63 * 3	Spacecraft position in ECR Coordinates (X, Y, Z) at MidTime_Solar	meters / 0 - None
spaceCraftVelocity Solar	Float32 * 63 * 3	Spacecraft velocity in ECR Coordinates (dx/dt, dy/dt, dz/dt) at MidTime_Solar	meters/sec / 0 - None

Input	Type/Size	Description	Units/Valid Range
spaceCraftAttitudeSolar	Float32 * 63 * 3	Spacecraft attitude with respect to Geodetic Reference Frame Coordinates (roll, pitch, yaw) at MidTime_Solar	arcsecond / roll: -648000 – 648000 pitch: -324000 – 324000 yaw: -648000 - 648000
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)	microseconds / 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
spaceCraftPositionDark	Float32 * 5 * 3	Spacecraft position in ECR Coordinates (X, Y, Z) at MidTime_Dark	meters / 0 - None
spaceCraftVelocityDark	Float32 * 5 * 3	Spacecraft velocity in ECR Coordinates (dx/dt, dy/dt, dz/dt) at MidTime_Dark	meters/sec / 0 - None
spaceCraftAttitudeDark	Float32 * 5 * 3	Spacecraft attitude with respect to Geodetic Reference Frame Coordinates (roll, pitch, yaw) at MidTime_Dark	arcsecond / roll: -648000 – 648000 pitch: -324000 – 324000 yaw: -648000 - 648000
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
spaceCraftPositionLamp	Float32 * 150 * 3	Spacecraft position in ECR Coordinates (X, Y, Z) at MidTime_Lamp	meters / 0 - None
spaceCraftVelocityLamp	Float32 * 150 * 3	Spacecraft velocity in ECR Coordinates (dx/dt, dy/dt, dz/dt) at MidTime_Lamp	meters/sec / 0 - None
spaceCraftAttitudeLamp	Float32 * 150 * 3	Spacecraft attitude with respect to Geodetic Reference Frame Coordinates (roll, pitch, yaw) at MidTime_Lamp	arcsecond / roll: -648000 – 648000 pitch: -324000 – 324000 yaw: -648000 - 648000

Input	Type/Size	Description	Units/Valid Range
QF1_GEOSOLAR	UInt8 * 63	Attitude/Ephemeris availability status during Solar Calibration	unitless / 0 - 3
QF2_GEODARK	UInt8 * 5	Attitude/Ephemeris availability status during Dark Calibration	unitless / 0 - 3
QF3_GEOLAMP	UInt8 * 150	Attitude/Ephemeris availability status during Lamp Calibration	unitless / 0 - 3
Pixel-Level Data Items			
latitudeSolar	Float32 * 63 * 740	Latitude of each FOV (positive North) at MidTIme_Solar	degrees / -90 - 90
longitudeSolar	Float32 * 63 * 740	Longitude of each FOV (positive East) at MidTime_Solar	degrees / -180 - 180

Table 38: OMPS Total Column SDR Output: Calibration SDR

Input	Type/Size	Description	Units/Valid Range
Granule-Level Data Items			
bias1	Float32	Average electronics bias CCD side 1	counts / 0 - none
bias2	Float32	Average electronics bias CCD side 2	counts / 0 - 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_solar_frames	Int16	Number of solar frames from working diffuser	unitless / TPsol_num - TPsol_num
no_ref_solar_frames	Int16	Number of solar frames from reference diffuser	unitless / 0 - 0
no_dark_frames	Int16	Number of dark frames (images)	unitless / TPdark_num - TPdark_num
no_lamp_frames	Int16	Number of lamp frames (images)	unitless / TPled_num - TPled_num
no_coadds_solar	Int16	Number of coadds during solar calibration	unitless / TPsol_conum - TPsol_conum
no_coadds_dark	Int16	Number of coadds during Dark calibration	unitless / TPdark_conum - TPdark_conum
no_coadds_lamp	Int16	Number of coadds during Lamp calibration.	unitless / TPled_conum - TPled_conum
total_sol_expose	Float64	Total solar exposure time	seconds / 0 - none
Scan-Level Data Items			
diffuser_position_solar	Int16 * 63 * 2	Starting and ending pixel column for each solar measurement	unitless / 1 - 7
rsf_expose	Float32	Reference solar exposure time (rsf_expose)	seconds / 0 - none
solar_beta1	Float32 * 63	Angle between orbital plane and sun at start of solar observation	degrees / -180 - 180

Input	Type/Size	Description	Units/Valid Range
solar_beta2	Float32 * 63	Angle between orbital plane and sun at end of solar observation	degrees / -180 - 180
diff_incid_angle	Float32 * 63	Angle from normal of incident solar flux	degrees / 0 - 90
iyear_solar	Int32 * 63	Year of Solar Observation	years / 2000 - 2050
iday_solar	Int32 * 63	Day of Year for Solar Observation	days / 1 - 366
diffuser_surface_solar	Int32 * 63	Diffuser Surface used for Solar Calibration	unitless / 0 - 2
tccdtc_solar	Int16 * 63	CCD Temperature	count / 0 - none
tmotnad_solar	Int16 * 63	Motor Temperature at Nadir	count / 0 - none
tlmpnad_solar	Int16 * 63	Lamp Temperature at Nadir	count / 0 - none
tradnad_solar	Int16 * 63	Radiator Temperature at Nadir	count / 0 - none
tel1nad_solar	Int16 * 63	Electronics 1 Temperature at Nadir	count / 0 - none
tel2nad_solar	Int16 * 63	Electronics 2 Temperature at Nadir	count / 0 - none
pccdtc_solar	Int16 * 63	Profile of CCD	count / 0 - none
vtectc_solar	Int16 * 63	Voltage of Electronics	count / 0 - none
ctectc_solar	Int16 * 63	Electronics current	count / 0 - none
tccdtc_dark	Int16 * 5	CCD Temperature	count / 0 - none
tmotnad_dark	Int16 * 5	Motor Temperature at Nadir	count / 0 - none
tlmpnad_dark	Int16 * 5	Lamp Temperature at Nadir	count / 0 - none
tradnad_dark	Int16 * 5	Radiator Temperature at Nadir	count / 0 - none
tel1nad_dark	Int16 * 5	Electronics 1 Temperature at Nadir	count / 0 - none
tel2nad_dark	Int16 * 5	Electronics 2 Temperature at Nadir	count / 0 - none
pccdtc_dark	Int16 * 5	Profile of CCD	count / 0 - none
vtectc_dark	Int16 * 5	Voltage of Electronics	count / 0 - none
ctectc_dark	Int16 * 5	Current of Electronics	count / 0 - none
tccdtc_lamp	Int16 * 150	CCD Temperature	count / 0 - none
tmotnad_lamp	Int16 * 150	Motor Temperature at Nadir	count / 0 - none
tlmpnad_lamp	Int16 * 150	Lamp Temperature at Nadir	count / 0 - none
tradnad_lamp	Int16 * 150	Radiator Temperature at Nadir	count / 0 - none
tel1nad_lamp	Int16 * 150	Electronics 1 Temperature at Nadir	count / 0 - none
tel2nad_lamp	Int16 * 150	Electronics 2 Temperature at Nadir	count / 0 - none
pccdtc_lamp	Int16 * 150	Profile of CCD	count / 0 - none
vtectc_lamp	Int16 * 150	Voltage of Electronics	count / 0 - none
ctectc_lamp	Int16 * 150	Current of Electronics	count / 0 - none
qual_lamp	Int16 * 150	Reliability of lamp processing	unitless / none - none
qual_solar	Int16 * 63	Reliability of solar processing	unitless / -4 - 5
qual_dark	Int16 * 5	Reliability of dark processing	unitless / none - none
median_dark	Float32	Median dark current	counts / none - none
fitness	Float64 * 105	Chi-squared goodness of fit for wavelengths	unitless / 0 - none

Input	Type/Size	Description	Units/Valid Range
completeFlag	Int16	Completeness of solar calibration data	unitless / 0 - 7
saa_lamp	UInt8 * 150	Spacecraft within South Atlantic Anomaly during Lamp calibration (extent in percent based on Climatological data)	unitless / 0 - 8
saa_solar	UInt8 * 63	Spacecraft within South Atlantic Anomaly during Solar calibration (extent in percent based on Climatological data)	unitless / 0 - 8
saa_dark	UInt8 * 5	Spacecraft within South Atlantic Anomaly during Dark calibration (extent in percent based on Climatological data)	unitless / 0 - 8
eclipse	UInt8 * 63	Eclipse - All or part of the S/C is affected by a solar eclipse, umbra or penumbra viewing.	unitless / 0 - 1
occult_flag	UInt8 * 63	Occultation of the diffuser during solar observation	unitless / 0 - 3
Pixel-Level Data Items			
dark_data	Float32 * 364 * 780	Dark current corrected coadded counts	counts / none - none
badpix	Float32 * 260 * 740	Map of pixels used for solar data	unitless / 0 - 1
wmap	Float64 * 260 * 740	Wavelenth map	unitless / 290 - 290
flat	Float32 * 260 * 740	Local relative normalized radiometric sensitivities	unitless / 0 - none
ccd	Float64 * 260 * 740	Count rate of sun	counts_per_second / none - none
rsf_data	Float32 * 260 * 740	Reference solar counts	counts / 0 - none
raw_solar	Float32 * 63 * 260 * 200	Raw Solar Radiances	counts / none - none
smear_data_solar	Float32 * 63 * 260 * 2	Smear Data Solar Radiances	counts / none - none
gon_par	Float32 * 63 * 260 * 200	Goniometric correction to solar counts	unitless / TBD - TBD
flux_data	Float32 * 63 * 260 * 200	Final corrected solar counts of individual solar observation	W/cm^3 / none - none
dark_array	Float32 * 5 * 364 * 780	Correct counts of an individual dark current image	counts / none - none
lamp_data	Float32 * 150 * 364*780	Correct counts of an individual lamp image	counts / none - none

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 34 for the detailed format of the Badpixels Auxiliary product and the IDFCB vol 3 for completeness.

Linear Proposed Upload

The Linearity proposed upload (see Table 27 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 35 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 Files

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

Table 39: Earth View Geolocation

Input	Type/Size	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 - 105
Scan-Level Data Items			
QF1_GEOSDR	UInt8 * 15	Attitude/Ephemeris availability status	unitless / 0 - 3
startTime	Int64 * 15	Starting Time of Swath in IET (1/1/1958)	microseconds / 0 - None
midTime	Int64 * 15	Mid Time of Swath in IET(1/1/1958)	microseconds / 0 - None
moonVector	Float32 * 15 * 3	Lunar position in Spacecraft Coordinates at MidTime	meters / 0 - None
sunVector	Float32 * 15 * 3	Solar position in Spacecraft Coordinates at MidTime	meters / 0 - None
spaceCraftPosition	Float32 * 15 * 3	Spacecraft position in ECR Coordinates (X, Y, Z) at MidTime	meters / 0 - None
spaceCraftVelocity	Float32 * 15 * 3	Spacecraft velocity in ECR Coordinates (dx/dt, dy/dt, dz/dt) at MidTime	meters/sec / 0 - None

Input	Type/Size	Description	Units/Valid Range
spaceCraftAttitude	Float32 * 15 * 3	Spacecraft attitude with respect to the Geodetic Reference Frame (roll, pitch, yaw) at MidTime	arcsecond / roll: -648000 – 648000 pitch: -324000 – 324000 yaw: -648000 - 648000
Pixel-Level Data Items			
latitude	Float32 * 15 * 105	Latitude of each IFOV (positive North)	degrees / -90 - 90
longitude	Float32 * 15 * 105	Longitude of each IFOV (positive East)	degrees / -180 - 180
latitudeCorner	Float32 * 15 * 105 * 4	Latitude of each IFOV Corner – Array starts at upper right and proceeds clockwise	degrees / -90 - 90
longitudeCorner	Float32 * 15 * 105 * 4	Longitude of each IFOV Corner - Array starts at upper right and proceeds clockwise	degrees / -180 - 180
solarZenithAngle	Float32 * 15 * 105	Zenith angle of sun at each IFOV position	degrees / 0 - 180
solarAzimuthAngle	Float32 * 15 * 105	Azimuth angle of sun (measured clockwise positive from North) at each IFOV position	degrees / 0 - 360
satelliteZenithAngle	Float32 * 15 * 105	Zenith angle to satellite at each IFOV position	degrees / 0 - 180
satelliteAzimuthAngle	Float32 * 15 * 105	Azimuth angle (measured clockwise positive from North) to Satellite at each IFOV position	degrees / 0 - 360
relativeAzimuthAngle	Float32 * 15 * 105	Difference between solar and satellite azimuth angles at each IFOV position (solar – satellite)	degrees / 0 - 360
height	Float32 * 15 * 105	Ellipsoid-Geoid separation	meters / 0 - None
satelliteRange	Float32 * 15 * 105	Line of sight distance from the ellipsoid intersection to the satellite	meters / 0 - None

Table 40: Earth View SDR

Input	Type/Size	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 / -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
darkExposeEarth	Float64	Integration time for dark data (expose_dark)	seconds / 0 - None
bias1	Float32	Average electronics bias CCD side 1	counts / 1.4E-45 - 3.4028235E3
bias2	Float32	Average electronics bias CCD side 2	counts / 1.4E-45 - 3.4028235E3
linearityTableVersion	UInt16 * 2	Version and Profile ID of on-board Linearity Table from RDR	Unitless / 0 – 65535

Input	Type/Size	Description	Units/Valid Range
gainTableVersion	UInt16 * 2	Version and Profile ID of on-board Gain Table from RDR	Unitless / 0 – 65535
tcLinearCor	UInt8 * 15	Indicates Linearity Correction performed inflight	Unitless / 0 - 1
SAA	UInt8 * 15	Spacecraft within South Atlantic Anomaly (extent in percent based on Climatological data)	Unitless / 0 - 8
qualEarth	Int16 * 15	Earth processing reliability (cumulative relative quality indicator count)	Unitless / 0 - None
smearDataEarth	Float32 * 15 * 2 * 260	Raw smear counts of Earth image	counts / 1.4E-45 - 3.4028235E38
radiancesEarth	Float32 * 15 * 105 * 260	Calibrated Earth View Radiances	W/(cm^3*sr) / 1.4E-45 - 3.4028235E38
wavelengths	Float64 * 105 * 260	Wavelengths used in SDR processing (wref)	nanometers / 290 - 390
solarFlux	Float32 * 105 * 260	Reference solar flux from calibration database (rsf_piece)	W/cm^3 / 0 - 1500
darkCurrentEarth	Float32 * 107*260	Dark current in earth data (dark_piece)	counts / 1.4E-45 - 3.4028235E38
cal	Float32 * 105 * 260	Radiometric calibration	W/(cm^3*sterad) / 0 - None
sunGlint	UInt8 * 15 * 105	Sun glint indication (scattering angle and surface type thresholds)	Unitless / 0 - None
solarEclipse	UInt8 * 15 * 105	All or part of the IFOV is affected by a solar eclipse, umbra or penumbra viewing.	Unitless / 0 - 1
waveFlag	UInt8 * 15 * 105	This data field is obsolete	Unitless / 0 - 1
radFlag	Float32 * 15 * 105	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 564 to be stored as OMPS TC Calibration RDRs. Similarly, only raw Earth View data received under APID 560 is stored as OMPS TC 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.

The processing of RDRs is driven by a series of sample tables which describe which pixels were used for each RDR – e.g. the Solar Calibration Sample Table is a map of which pixels were used in the Solar Calibration frame observations. The tables describe the locations of smear pixels as well as observation pixels. During the mission, changes to the flight software sample tables are synchronized with the sample tables used by the ground software to maintain sampling integrity.

Earth view processing is presented in Section 3.1.2 of the TC ATBD, 474-00029, and calibration processing is discussed in D43774, Section 3.1.3.

2.1.2.1 Calibration Main Science Module - tc_pipeline_cal.f

The **tc_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.f** to define the OMPS TC 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 **tc_process_pipe_cal.f** to perform the science processing for a Calibration RDR.

2.1.2.1.1 Subroutine tc_process_pipe_cal.f

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

2.1.2.1.2 Subroutine RDF_input_cal.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 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**.

This subroutine calls **read_RDR_hdr_cal**, **rdr_limits**, **save_rdr_hdrs**, **fill_limit_flags**, **FullCCD2clipwsmear**. It is called by **tc_pipeline_cal**.

2.1.2.1.3 Subroutine Read_spec_cal.f

This subroutine inputs low resolution solar reference spectrum. It is called by **tc_process_pipe_cal** and **Wave_monitor_tc**.

2.1.2.1.4 Subroutine tc_calib.f

The calibration subroutine performs numerous steps in processing the calibration images. It follows the steps found in the TC ATBD, 474-00029, 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 - tc_pipeline_earth.f

The **tc_pipeline_earth.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,** 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 calibrating radiances. This function calls **Get_instrum_params.f** to define the OMPS TC sensor parameters (CCD reference angles, CCD spatial map, CCD spectral map, and channel spectral functions). It also calls **RDF_input_earth.f** to gather both engineering and raw CCD data from the verified RDR. Finally, this function calls **tc_process_pipe.f** to perform the science processing for an Earth View RDR.

2.1.2.2.1 Subroutine tc_process_pipe_earth.f

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

2.1.2.2.2 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_cal.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 **tc_pipeline_earth**.

2.1.2.2.3 Subroutine Read_spec_earth.f

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

2.1.2.2.4 Subroutine tc_earth_view_earth.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 TC ATBD, 474-00029. The routine **tc_earth_view.f** starts with some initialization for stray light. Then it continues by calling **Get_bias.f** to collect bias data from the Biases auxiliary input to be used in subtracting from all Earth view data by **sub_bias_earth.f**. Next, the dark data is collected 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.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 macro-pixels are then checked and flagged for unusually high radiances. Finally, **sdr_write_earth.f** stores the Earth radiances within the Earth view SDR in shared memory.

The bias, dark, and smear corrections are discussed in TC ATBD, 474-00029, Section 3.1.2.6. The stray light correction is discussed in TC ATBD, 474-00029, Section 3.1.2.7. The radiometric correction is presented in TC ATBD, 474-00029, Section 3.1.2.8. 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 the EV executable.

2.1.2.3.1 Subroutine Get_evtable.f

Get_evtable.f interprets the EV sample table and determines bad pixels. badpixBATC contains 0 for bad pixels and 1 for good. This array is used in the calculations during processing rather than bad_pixels. It is called by **tc_pipeline**.

2.1.2.3.2 Subroutine Get_macrotable.f

Get_macrotable interprets the macrotable input. The bspec, bspecrange, bspat, bspatrange and nmacro array variables are determined here. Also the macro pixel informational arrays are determined: macview_npix, macview_pixloc, macview_nom, macsmear_npix, macsmear_pixloc, macinfo (see Appendix A. Array Dimensions and Coordinate Systems for description). It is called by **tc_pipeline_cal** and **tc_pipeline_earth**.

2.1.2.3.3 Subroutine IntFullCCD2viewonly.f

IntFullCCD2viewonly.f converts an integer input array that is in full CCD array coordinates into an integer output array in CVO (clipped view only) coordinates. It is called by **get_bad_pixels**.

2.1.2.3.4 Subroutine Get_sctable.f

Get_sctable.f interprets the SC sampletable. The diffuser pixel boundaries for each of the seven diffuser locations are determined here. The arrays bsolspat and bsolspec are calculated in this routine (See Appendix A. Array Dimensions and Coordinate Systems for description). It is called by **tc_pipeline_cal**.

2.1.2.3.5 Subroutine Get_ledtable.f

Get_ledtable.f interprets the LED sampletable. The locations of the lamp sample pixels are read. These pixels are randomly scattered on the CCD. Lampsample is this array in full CCD coordinates. The value of 0 means not used; values of 1 and 2 are used. It is called by **tc_pipeline_cal**.

2.1.2.3.6 Subroutine Get_timetable.f

Get_timetable.f interprets the timing pattern table. The data in this table is then used to calculate integration times, coadd numbers and start times. It is called by **tc_pipeline_cal** and **tc_pipeline_earth**.

2.1.2.3.7 Subroutine Get_instrum_params.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, data 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 **tc_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 **tc_pipeline_cal** and **tc_pipeline_earth.**

2.1.2.3.8 Subroutine Get_optical_angles.f

Get_optical_angles.f extracts data from the Field Angles Map LUT and stores values in array *angels* [sic]. It is called by **tc_pipeline_cal** and **tc_pipeline_earth**.

2.1.2.3.9 Subroutine Read_wave_ref.f

This subroutine uses values from the Spectral Registration Pixel Map LUT to store in array *wmap*. It is called by **Get_instrum_params**.

2.1.2.3.10 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**.

2.1.2.3.11 Subroutine FullCCD2viewonly.f

This subroutine converts data from Full Array coordinates to CVO coordinates. It is called by **get_bad_pixels**, **Read_resp**, **Read_solar_ref**.

2.1.2.3.12 Subroutine read_RDR_hdr_cal.f

This subroutine, as well as the reader subroutines that it calls, reads the header parameters listed in the MDFCB 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. Start times of each observation are calculated from the ending observation times and observation integration period defined in the Timing Pattern Table.

For Calibration data, N_PROFILE_ID is used to distinguish the dataform (LAMP=18, DARK=11, SOLAR diffuser positions 1 thru 7: 21 thru 27). Full frame data is ignored (LEDff=16 and DRKff=2). Note that TC_ROWS and TC_COLS are not indicative of the quantity of CCD data in the RDR. Sample tables must be consulted for that information. It is called by **RDF_input_cal** and **RDF_input_earth**.

2.1.2.3.13 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**.

2.1.2.3.14 Subroutine save_rdr_hdrs.f

This subroutine transfers header variables into storage arrays by data type (EARTH, DARK, LAMP or, SOLAR). It is called by **RDF_input_cal** and **RDF_input_earth**.

2.1.2.3.15 Subroutine fill_limit_flags.f

This subroutine transfers limits flags into storage arrays by data type (EARTH, DARK, LAMP or, SOLAR). It is called by **RDF_input_cal** and **RDF_input_earth**.

2.1.2.3.16 Subroutine FullCCD2clipwsmear.f

This subroutine converts an input array that is in full CCD array coordinates into CWS (clipped with smear). It is used for converting to dark_array and flux_data. The routine takes into account that the dark_array has the smear in pixels and the flux_data smear is in macropixels. It is called by **RDF_input_cal** and **RDF_input_earth**.

2.1.2.3.17 Function Get_instrum_params.f

Get_instrum_params.f inputs a series of sensor parameters. Optical angles, radiance response, irradiance response, Wmap, waves, linearity table are all read in from here.

Get_instrum_params.f calls **Get_optical_angles**, **read_resp**, and **Read_wave_ref** and is also called by **tc_pipeline** and **cal**, **tc_pipeline_earth**.

2.1.2.3.18 Subroutine Band_center_read.f

If the Wavelengths auxiliary input does not exist, this subroutine sets band center wavelengths to original values. If input exists, this subroutine selects wavelengths and supporting data entries for the same day as the current Earth view data. It is called by **tc_process_pipe_cal** and **tc_process_pipe_earth**.

2.1.2.3.19 Subroutine Flag_waves.f

This subroutine performs statistical analysis of wavelengths assigned to each Earth View swath, wavelength flag is set if wavelengths fall outside pre-determined min/max range. It calls **Stats4** and is called by **tc_process_pipe_earth**.

2.1.2.3.20 Subroutines Stats.f and Stats4.f

Subroutines **Stats** and **Stats4** compute median, mean, standard deviation, min and max values of double array x of n elements. **Stats** is called by **Wave_monitor_tc**, **Wave_trend**. **Stats4** is called by **Flag_waves**, **StatsCWS2mac37**, and **tc_earth_view_earth**.

2.1.2.3.21 Subroutine Get_bias.f

Get_bias collects the most recent value for each side of the CCD from the Biases auxiliary input. Biases are now calculated from dark data. **Get_bias** is called by **tc_calib**, **tc_earth_view_earth**.

2.1.2.3.22 Subroutine Linearity.f

This subroutine 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 no longer used in processing, but are used to propose new linearity corrections for use in the next linearity upload. Instead the Linearity LUT, which is based on human-reviewed coefficients, is used for processing. The appropriate Linearity LUT is selected by matching linearity correction table ID and version from that listed in the RDR Telemetry. **Linearity.f** is called by **tc_calib**.

2.1.2.3.23 Subroutine sub_bias_dark.f

Subroutine **sub_bias_dark** subtracts the biases, bias1 and bias2, from all dark frames. TC ATBD, 474-00029, Section 3.1.3.4.3 also discusses this process. **sub_bias_dark** is called by **tc_calib**.

2.1.2.3.24 Subroutine Linearize_dark.f

Subroutine **Linearize_dark** applies to the dark data a linearity correction using the Linearity LUT. The correction is based on the raw count levels of the data itself. All dark images are corrected. TC ATBD, 474-00029, Section 3.1.3.4.3 also discusses this process.

2.1.2.3.25 Subroutine sum_darks.f

Dark data from all dark RDRs, in the RDF that is processed, 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 TC ATBD, 474-00029, Section 3.1.3.4.6. **sum_darks.f** is called by **tc_calib**.

2.1.2.3.26 Subroutine do_stats.f

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

2.1.2.3.27 Subroutine sdr_write_SAA_dark.f

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

2.1.2.3.28 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.

2.1.2.3.29 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. **read_dark** is called by **sub_dark_earth**, **tc_calib**.

2.1.2.3.30 Subroutine sdr_write_dark.f

This subroutine stores Dark data to the Darks auxiliary product. Only dark RDRs not affected by SAA are stored in this product. **sdr_write_dark.f** is called by **tc_calib**.

2.1.2.3.31 Subroutine sdr_write_lamp.f

This subroutine stores the raw individual lamp frames that went into the linearity correction. This data is stored in the Lamps auxiliary output.

2.1.2.3.32 Subroutine sub_bias_solar.f

Subroutine **sub_bias_solar** subtracts the biases, bias1 and bias2, from all solar frames. TC ATBD, 474-00029, Section 3.1.3.4.3 also discusses this process. Flux_data is in CWS coordinates and the smear pixels are macropixels. **sub_bias_solar** is called by **tc_calib**.

2.1.2.3.33 Subroutine Save_bias.f

This subroutine stores both bias values, bias1 and bias2, to the Biases auxiliary output. **Save_bias.f** is called by **tc_calib**.

2.1.2.3.34 Subroutine Linearize_solar.f

Subroutine **Linearize_solar** applies to the solar data the linearity correction based on the Linearity LUT. All solar frames are corrected. TC ATBD, 474-00029, Section 3.1.3.4.3 also discusses this process. **Linearize_solar** is called by **tc_calib**.

2.1.2.3.35 Subroutine sub_dark_solar.f

Subroutine **sub_dark_solar** subtracts the dark, pixel by pixel, from the solar data. TC ATBD, 474-00029, Section 3.1.3.4.3 also discusses this process. **sub_dark_solar** is called by **tc_calib**.

2.1.2.3.36 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. Calculation of the smear is performed within the subroutine based on the macrotable. TC ATBD, 474-00029, Section 3.1.3.4.3 also discusses this process. **subtract_smear_solar** is called by **tc_calib**.

2.1.2.3.37 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 BRDF grid input (including its associated angular grid) for each CCD pixel for each diffuser position is used and then 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.

TC ATBD, 474-00029, Section 3.1.3.4.6 expands on this discussion. In addition, it should be noted that under operational conditions when the goniometry data is not needed then the goniometry tunable parameter can be disabled. When the goniometry results are needed the tunable parameter is enabled.

2.1.2.3.38 Subroutine Read_solar_ref.f

Subroutine **Read_solar_ref** gets the Day 1 Reference Solar Flux (rsf) from the Observed Solar LUT and reformats the data using **FullCCD2viewonly.f**. **Read_solar_ref** calls **FULLCCD2viewonly** and is called by **tc_calib**, **tc_earth_view_earth**.

2.1.2.3.39 Subroutine Combine_solar.f

Subroutine **Combine_solar** combines the solar CCD data frames into a complete solar image. The separate solar segments from the different diffuser positions are combined into a single solar image by averaging the counts separately at each position and then spatially combining the average counts from the different positions in order to obtain a complete solar count image. This stitching assumes that the exposure times of the different positions for a given diffuser surface are the same! If less than half of the positions are missing from the current set, the subroutine reads the newest solar data from the Rawflux auxiliary input and fills in the missing data.

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 bad pixel 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, 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 (700 x 192) data array by removing the smear columns from the array.

The tunable parameter is DiffEndEdges, which specifies where to stitch the Diffuser Ends together to form a single output. The outputs are counts_ccd, rawflx_data, and CCD. **Combine_solar** calls **Read_rawflux_tc** and is called by **tc_calib**.

The equation describing this process is found in TC ATBD, 474-00029, Sections 3.1.3.4.6 and 3.1.3.4.7.

2.1.2.3.40 Subroutine Read_rawflux_tc.f

Subroutine **Read_rawflux_tc** loads data from the Rawflux auxiliary input. Variables in COMMON with the main Total Column pipeline software are passed through F90 modules. **Read_rawflux_tc** is called by **Combine_solar**.

2.1.2.3.41 Subroutine Rawflux_write_tc.f

Subroutine **Rawflux_write_tc** 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. The reference solar flux and counts arrays are stored. Variables in COMMON with the main Total Column 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. **Rawflux_write_tc** is called by **tc_calib**.

2.1.2.3.42 Subroutine Wave_monitor_tc.f

This subroutine, **Wave_monitor_tc**, 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 froms 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** 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**, **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**, **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.

The tunable parameter DiffEndEdges specifies where to stitch the Diffuser Ends together to form a single output.

TC ATBD, 474-00029, Section 3.1.3.5.6 develops the continuum fitting approach to wavelength monitoring while Section 3.1.3.5.7 develops the discrete line approach.

2.1.2.3.43 Subroutine Read_table_ref_shifts.f

Subroutine **Read_table_ref_shifts** loads date 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.

2.1.2.3.44 Subroutine interpolate.f

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

2.1.2.3.45 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.

2.1.2.3.46 Subroutine init_wshifts.f

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

wmin, wmax are the wavelength extrema
nlines is the number of discrete spectral lines monitored
good is a condition flag for program execution.

It is written only if a Wave Monitor auxilariy input was not retrieved.

2.1.2.3.47 Subroutine GenSplineInterp.f

This subroutine was written to replace the spline and splint subroutines from Numerical Recipes.

2.1.2.3.48 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**. 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.

2.1.2.3.49 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.

2.1.2.3.50 Subroutine Write_wshifts.f

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

2.1.2.3.51 Subroutine Wave_trend_tc.f

Using previously measured wavelength shifts of a two-dimensional spectral-spatial detector, the subroutine **Wave_trend_tc**, predicts the central wavelengths of all pixels in a spectrum for each recorded spatial channel, for each extrapolated day, and insertss the expected wavelengths into the Wavelengths auxiliary output. The most recent wavelength shift values are first read from a Wavelengths 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 always supercede older, extrapolated values.

Wavelength trending over time is discussed in TC ATBD, 474-00029, Section 3.1.3.5.8.

2.1.2.3.52 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.

2.1.2.3.53 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. **Shift_correct.f** calls subroutine **GenSplineInterp.f**.

This correction is discussed in TC ATBD, 474-00029, Section 3.1.3.4.8.

2.1.2.3.54 Subroutine Flux_write_tc.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 Total Column pipeline software are passed through F90 modules.

2.1.2.3.55 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. The tunable parameter is TrendGapMax, which is how many days tolerated between cal events before you cannot do trending. This processing is described in TC ATBD, 474-00029, Sections 3.1.3.5.4 and 3.1.3.5.5.

2.1.2.3.56 Subroutine linfit.f

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

2.1.2.3.57 Subroutine AvgCVO2mac35.f

This subroutine converts a CVO array (clipped view only) into a macro 35 array. This is done by averaging the pixels using the information from the mac35_npix and mac35_pixloc arrays.

2.1.2.3.58 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.

2.1.2.3.59 Subroutine sub_bias_earth.f

For each half of the image, the subroutine **sub_bias_earth** subtracts sensor electronics biases from all Earth view frames, using the bias values from the newest solar data.

2.1.2.3.60 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) rebinning 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.

2.1.2.3.61 Subroutine AvgCWS2mac37

This subroutine converts a CWS array (clipped with smear) into a macro37 array. This is done by averaging the pixels using the information from the macro_npix and macro_pixloc arrays.

2.1.2.3.62 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.

2.1.2.3.63 Subroutine subtract_smear_earth.f

This subroutine calculates, with **calc_smear_earth.f,** the smear for both halves of the CCD and then subtracts the smear from the earth data. Special processing is needed for the middle macropixel since it is formed from pixels on both sides of the CCD. A weighted smear is calculated for this middle pixel taking into account the smear and the number of good pixels on both sides.

2.1.2.3.64 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 first nosmear rows and in the last 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.

The subroutine assumes that the CCD data is contiguous -- i.e. one does not have to worry about reassembling the two halves of the CCD while doing this – they are already stitched together as a single array (or data cube for multiple RDRs).

2.1.2.3.65 Subroutine Read_cal_factors_tc.f

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

2.1.2.3.66 Subroutine sdr_write_earth.f

This subroutine stores Earth View radiances to the Earth View SDR.

2.1.2.3.67 Subroutine sol_wscale_shift.f

This subroutine estimates the Earth-view radiances wavelength scale relative to the solar spectrum wavelength scale and returns the new wavelength scale and an appropriately adjusted solar spectrum.

2.1.3 Graceful Degradation

None unique to TC SDR, the process however can have GD related to granulation of ANC.

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.

Potential 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.

Any exceptions or errors are reported to IDPS using the appropriate INF API.

2.1.5 Data Quality Monitoring

None.

2.1.6 Computational Precision Requirements

The OMPS TC 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 **gonimetry.f** subroutine. In general, wavelength computations (*_wshifts.f, Wave_monitor_tc.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 is available and provided within the necessary time constraints.

When tasked with a calibration granule that lacks necessary images, the calibration executable rejects the task and sends an SDR_NOACTION message to INF. Similarly, if reference solar data is detected, a descriptive message is 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 contains terms most applicable for this OAD.

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.
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]
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.

3.2 Acronyms

Table 42 contains terms most applicable for this OAD.

Table 42: Acronyms

Term	Expansion
ADCS	Advanced Data Collection System
ADS	Archive and Distribution Segment
AFB	Air Force Base
AFM	Airborne Fluxes and Meteorology Group
AFSCN	Air Force Satellite Control Network
AFWA	Air Force Weather Agency
AFWWS	Air Force Weather Weapon System
AGE	Aerospace Ground Equipment
AIAA	American Institute of Aeronautics and Astronautics
ANSI	American National Standards Institute
Ao	Operational Availability
AOS	Acquisition of Signal
ARP	Application-Related Products
ARF	Anisotropic Reflectance Factor
ATMS	Advanced Technology Microwave Sounder
BATC	Ball Aerospace and Technologies Corporation
BIT	Built-in Test
BITE	Built-in Test Equipment
BMMC	Backup Mission Management Center
BRDF	Bi-directional Reflectance Distribution Function
C2	Command and Control
C3S	Command, Control, and Communications Segment
CCSDS	Consultative Committee for Space Data Systems
CCD	Charge Coupled Device
CDA	Command and Data Acquisition
CDDIS	Crustal Dynamics Data Information System
CDR	Climate Data Records
CERES	Cloud and Earth Radiant Energy System
CGMS	Coordination Group for Meteorological Satellites
CI	Configured Item
CLASS	Comprehensive Large-Array data Stewardship System
CMIS	Conical Microwave Imager Sounder
CMOC	Cheyenne Mountain Operations Center
COMSAT	Communications Satellite
COMSEC	Communications Security
CONUS	Continental United States
COTS	Commercial Off the Shelf
CrIMSS	Cross-Track Infrared Microwave Sounding Suite
CrIS	Cross-Track Infrared Sounder
CSCI	Computer Software Configured Item
CVO	Clipped View Only
CWS	Clipped With Smear
DCP	Data Collection Platforms

Term	Expansion
DES	Digital Encryption System
DFCB	Data Format Control Book
DHN	Data Handling Node
DMSP	Defense Meteorological Satellite Program
DNB	Day/Night Band
DOC	Department of Commerce
DoD	Department of Defense
DRR	Data Routing and Retrieval
EDR	Environmental Data Records
EELV	Evolved Expendable Launch Vehicle
EMC	Electromagnetic Compatibility
EMD	Engineering and Manufacturing Development
EOL	End of Life
EOS	Earth Observing System
ERBS	Earth Radiation Budget Suite
ESD	Electrostatic Discharge
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
EWR	Eastern and Western Ranges
FFRDC	Federally Funded Research and Development Center
FMH	Federal Meteorological Handbook
FNMOC	Fleet Numerical Meteorology and Oceanography Center
FOC	Full Operational Capability
FTS	Field Terminal Segment
FVS	Flight Vehicle Simulator
GFE	Government Furnished Equipment
GIID	General Instrument Interface Document
GMT	Greenwich Mean Time
GN	NASA Ground Network
GPS	Global Positioning System
GPSOS	GPS Occultation Suite
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
GVVSLE	Gain Value Versus Scene Lunar Elevation
GVVSSE	Gain Value Versus Scene Solar Elevation
HIJACK	Data Conversion Software
HDF	Hierarchical Data Format
HRD	High Rate Data
IAW	In Accordance With
ICD	Interface Control Document
IDPS	Interface Data Processor Segment
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IGS	International GPS Service
IJPS	Initial Joint Polar System
ILS	Integrated Logistics Support
IOC	Initial Operational Capability
IORD	Integrated Operational Requirements Document
IOT&E	Initial Operational Tests & Evaluation

Term	Expansion
IPL	Integrated Priority List
IPO	Integrated Program Office
IRD	Interface Requirements Document
ISO	International Standards Organization
ITRF	International Terrestrial Reference Frame
ITU	International Telecommunications Union
JSC	Johnson Space Center
JTA	Joint Technical Architecture
km	kilometer
LEO&A	Launch, Early Orbit, & Anomaly Resolution
LOS	Loss of Signal
LP	Limb Profiler
LRD	Low Rate Data
LSS	Launch Support Segment
LST	Local Solar Time
LUT	Look-up Table
LV	Launch Vehicle
MDT	Mean Down Time
METOP	Meteorological Operational Program
MMC	Mission Management Center
MOU	Memorandum of Understanding
MSS	Mission System Simulator
MTBCF	Mean Time Between Critical Failures
MTBDE	Mean Time Between Downing Events
MTTRF	Mean Time to Restore Function
NA	Non-Applicable
NACSEM	NPOESS Acquisition Cost Estimating Model
NASA	National Aeronautics and Space Administration
NAVOCEANO	Naval Oceanographic Office
NCA	National Command Authority
NCC	Near Constant Contrast
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanic and Atmospheric Administration
NORAD	North American Aerospace Defense Command
NPOESS	National Polar-Orbiting Environmental Satellite System
NPP	NPOESS Preparatory Program
NSA	National Security Agency
NTIA	National Telecommunications Information Agency
O&M	Operations and Maintenance
OLS	Operational Linescan System
OMPS	Ozone Mapping and Profiling Suite
P3I	Potential Pre-planned Product Improvements
PHS&T	Packaging, Handling, Storage, and Transportation
IP	Program Implementation Plan
PM&P	Parts, Materials, and Processes
PMT	Portable Mission Terminal
POD	Precise Orbit Determination
POES	Polar Orbiting Environmental Satellite

Term	Expansion
RDR	Raw Data Records
RPIE	Real Property Installed Equipment
S&R	Search and Rescue
SARSAT	Search and Rescue Satellite Aided Tracking
SCA	Satellite Control Authority
SDC	Surface Data Collection
SDE	Selective Data Encryption
SDP	Software Development Plan
SDR	Sensor Data Records
SDS	Science Data Segment
SESS	Space Environmental Sensor Suite
SI	International System of Units
SMD	Stored Mission Data
SN	NASA Space Network
SOC	Satellite Operations Center
SRD	Sensor Requirements Documents
SS	Space Segment
STDN	Spaceflight Tracking and Data Network
SVE	Space Vehicle Equipment
TBD	To Be Determined
TBR	To Be Resolved
TBS	To Be Supplied
TC	Total Column
TDR	Temperature Data Records
TDRSS	Tracking and Data Relay Satellite System
TEMPEST	Telecommunications Electronics Material Protected from Emanating Spurious Transmissions
TOA	Top of the Atmosphere
TRD	Technical Requirements Document
TSIS	Total Solar Irradiance Sensor
USAF	United States Air Force
USB	Unified S-band
USG	United States Government
UTC	Universal Time Coordinated
OMPS	Ozone Mapping and Profiler Suite

4.0 OPEN ISSUES

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

Table 43: TBXs

TBX ID	Title/Description	Resolution Date
None		

5.0 APPENDIX A. ARRAY DIMENSIONS AND COORDINATE SYSTEMS

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 Total Column sensor. The original assumption of a uniform data structure (all used data contained on the same 780 x 192 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 Total Column Sample Table and Bad Pixel Database (IN0092SDB-007) outline how the macropixel sizing can vary depending on the SPATIALFLAG setting. **Table 44** shows the coordinate system array names and their dimensions, and **Table 45** 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.

Table 44: Coordinate System Summary

Coordinate System	Dimensions - Initialization	Dimensions-Working.
Full Array	no_spat_ccd x max_nspec_ccd = 780 x 364	same
Clipped With Smear (CWS)	no_spat_ccd x max_nspec_ccd	bsmearange(3) + bspatrange(3) x bspecrange = 732 x 192 in the test data
Clipped View Only	no_spat_ccd x max_nspec_ccd	bspatrange(3) x bspecrange = 700 x 192 in the test data

Note: the test data are uniform in dimension. The values for the test data for each parameter are given in italics in the definition. See **Table 45**

Table 45: Coordinate System Parameter Definitions

Parameter	Definition and Notes
bspat	8 element array containing the endpoints for the spatial views and smear for each CCD. Unlike the spectral dimension, these are the same for each spectral row. 1-2: start and end pixels of view on CCD1 (*18,370*) 3-4: start and end pixels of smear on CCD1 (*377,388*) 5-6: start and end pixels of smear on CCD2 (*398,407*) 7-8: start and end pixels of view on CCD2 (*411,460*)
bspatrange	3 element array: bspatrange(1): number of view pixels in the spatial direction for CCD1 (*353*) bspatrange(2): number of view pixels in the spatial direction for CCD2 (*353*) bspatrange(3): total number of view pixels in the spatial direction (*700*)

bsmearange	3 element array: bsmearange(1): number of smear pixels in the spatial direction for smear region 1 (*12*) bsmearange(2): number of smear pixels in the spatial direction for smear region 2 (*12*) bsmearange(3): total number of smear pixels in the spatial direction for smear (*24*)
bspecrange	bspec(2) - bspec(1) + 1 (*192*)
bspec	2 element array: start and end pixels for the spectral range of the bounding box that encompasses all the spectral pixels that are used in the data collection. Due to the spectral shift, bspec(1) and bspec(2) are not necessarily the spectral start and end points for each spatial column. Rather they are the min and max values found for all the spatial columns. (*87,278*)
bsolspec	6 element array: bsolspec (1 – 2) = start and stop of the CCD1 overclock pixels bsolspec (3 – 4) = start and stop of the solar view pixels bsolspec (5 – 6) = start and stop of the CCD2 overclock pixels Note that bsolspec 1,2,5 and 6 are currently in the BATC sample table but may not be there in operations since the current baseline does not send down the overclock pixels in the solar data (we will be using the dark data for the overclock pixels which are used to calculate biases).
bsolspat	6x7 element array: bsolspat (x,1 – 7) corresponds to each of the 7 diffuser positions bsolspat(1,k) = start pixel of the solar view area for diffuser k bsolspat(2,k) = stop pixel of the solar view area for diffuser k bsolspat(3,k) = start of the smear view area for diffuser k bsolspat(4,k) = stop of the smear view area for diffuser k bsolspat(5,k) = start of the total view area for diffuser k bsolspat(6,k) = stop of the total view area for diffuser k
no_spat_ccd	= 780: total number of spatial pixels on the CCD; used for initializing the fully array CCD in the spatial direction
max_nspec_ccd	= 364: maximum number of pixels in the spectral direction on the CCD - used for initializing full array CWS and CVO arrays in the spectral direction
no_spat_pix	used to initialize array to maximum size of the CWS and CVO arrays in the spatial direction (*740*)

Full Array

All the BATC input databases/tables are in full CCD array sizing (780x364, no_spat_ccd by max_nspec_ccd in the code). The full CCD array coordinate system is diagrammed in Figure 4. The sample tables, macrotable, solar cal, and earth view are read in and the pixel values that are in these arrays are in the full CCD array coordinates. From these data, the arrays in Figure 4 and parameters in **Table 44** are calculated.

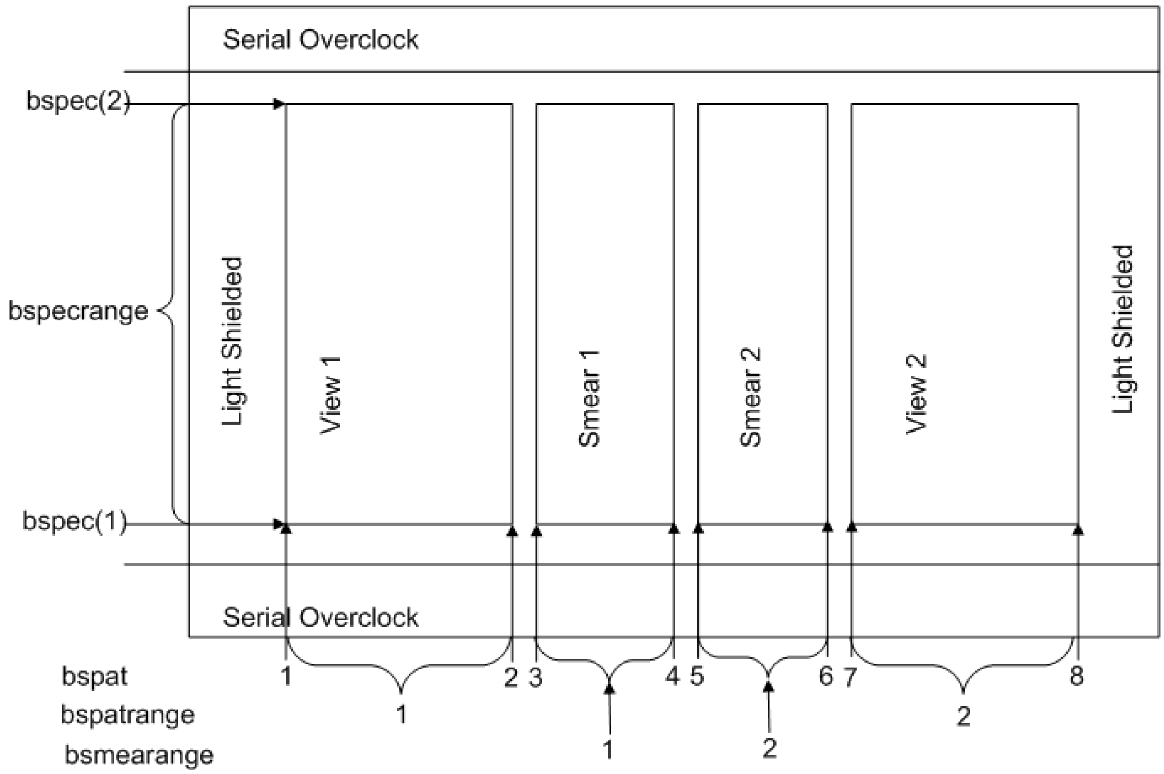

Figure 4: Full CCD Array Coordinate System

The following descriptions of the clipped views are examples only, appropriate for the NCT4 proxy data. The actual specific numbers will change for real data.

Clipped With Smear (CWS)

Most of the processing of cal data is done in CWS (clipped with smear) coordinates. This arranges the data from the full array to what is shown in Figure 5.

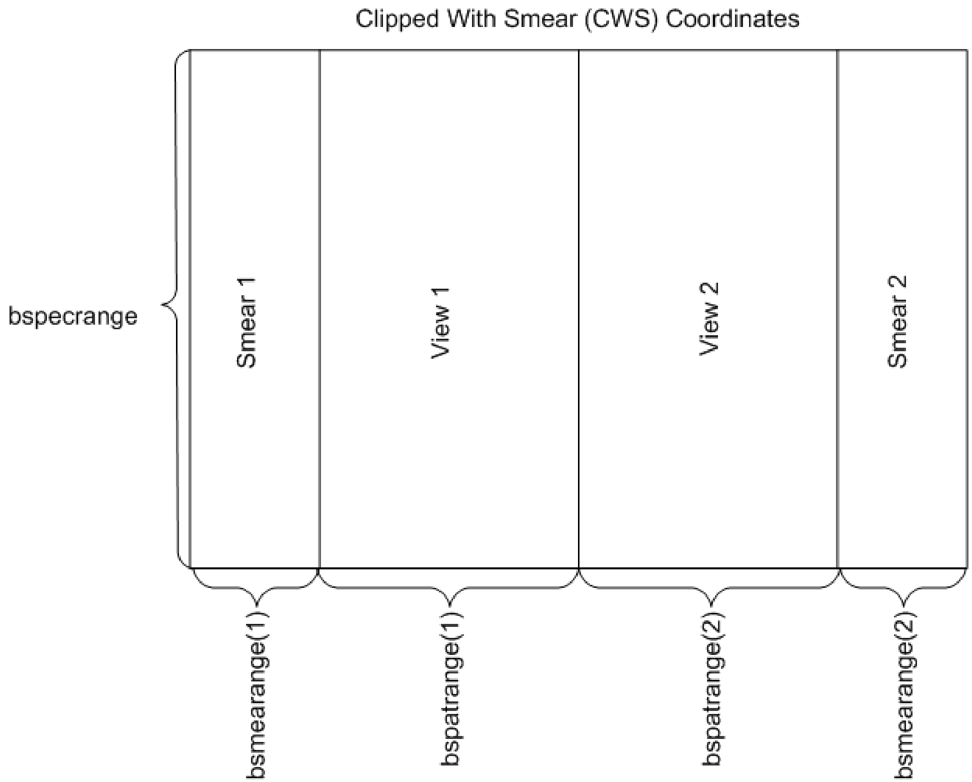

Figure 5: Clipped With Smear Coordinate System

In the spatial direction, all the light shielded pixels have been removed and the smear has been placed outside the view region. In the spectral direction, the overclock and unused pixels have been removed. In the original TC SDR code, the size of this array was nominally 740 x192. In the updated code, the array is 732 x 192. This is due to that fact that there are only 16 active smear pixels in each of the CCD (out of potential 20). Most of the calibration arrays, dark_array, lamp_data, flux_data, lamp_flux are in these coordinates.

Clipped View Only (CVO)

Subtracting the smear columns from CWS gives the CVO array coordinates which is clipped view only. This is just comprised of the View 1 and View 2. See Figure 6. The test data has the size of 700 x 192 or bspatrange(3) by bspecrange. The arrays response, rsf_data, rsf_counts, counts_ccd, ref_counts and hits are in these coordinates.

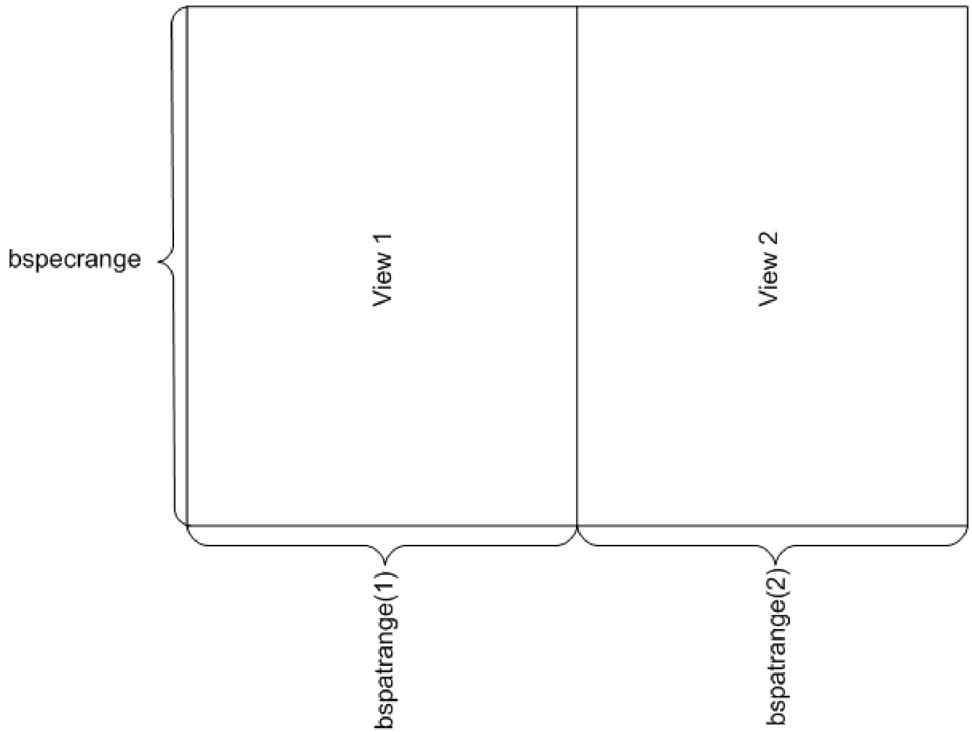

Figure 6: Clipped View Only Coordinate System

Macropixel Coordinates

For the earth data, much of the calculations are done in macropixels. All the macropixels tables have the same spectral size of bspecrange (192 for the test data). But there are three variations of the spatial macropixel coordinates which are based on different macropixel spatial numbering.

mac38 Coordinates

The macrotable input is in the macro coordinates. This has 38 "macropixels". There are 17 macropixels for the view on each CCD. There are two macropixels on each side for the center pixel. There are two smear pixels. The numbering of the macropixels in the macro (38) coordinates is:

1-17 = view on CCD1
18 = part of center macropixel on CCD1
19= smear macropixel on CCD1
20 = smear macropixel on CCD2
21 = part of center macropixel on CCD2
22-38 = view on CCD2

mac37 Coordinates

The earth data comes in macro coordinates of 37 macropixels. Most of the earth processing is done in this array sizing. The center pixel is already combined in this system. And the two smear pixels are on the outside of the array. The numbering is:

1= smear macropixel on CCD1
2-18 = view on CCD1
19 = center macropixel (already combined)
20-36 = view on CCD2
37 = smear macropixel on CCD2

mac35 Coordinates

The mac35 coordinates are simply the 1-35 view macropixels.

Additional Comments on Macropixel Coordinates

There are several arrays associated with the macropixel sampling. The mac38_ccd, mac37_cws, and mac35_cvo are all arrays that represent the pixels and the value in the array is the id number of the macropixel that that pixel is part of. The macro_* arrays have the id number running from 1-38*bspecrange. That is the macropixel ids are numbered 1-38 for each spectral row because they are in macro coordinates. But the array dimensions itself are determined by the *_ccd, cws, or cvo.

mac38_ccd = an array in full CCD coordinates, id value contained in the array is in macro (allowing 38 macropixels) coordinates

mac37_cws = an array in CWS (clippedwsmear) coordinates; id values contained in the array are in macro coordinates.

mac35_cvo = array in CVO (clippedviewonly) coordinates; id values contained in the array in mac35 coordinates (runs 1-35 for each row; so max id value = 35*bspecrange). There are no smear pixels and the center pixel has been combined. But there are no id values missing since the id numbers have been renumbered to only include the view pixels (35 of them in each spectral row).

The macropixels are also defined with their characteristics. The number of pixels and the locations of those pixels are defined in macxx_npix and macxx_pixloc. mac37_npix has 37 macropixels (35 view plus two smear) and is in CWS coordinates. mac35_npix has 35 macropixels (view only) and is in CVO coordinates.

mac37_npix (37, spectral rows) = no of pixels in that macropixel
mac37_pixloc (37, spectral rows, 20, 2) =
37 = macro pixel in the spatial direction
Spectral row = macro pixel in the spectral dimension
20 = 1- macro_npix for that pixel; that is 1 for each pixel making up the macropixel
4^{th} dimension: 1=spatial full CCD coordinate for the pixel making up the macropixel in CWS coordinates;
2 = spectral full CCD coordinate for the pixel making up the macropixel in CWS coordinates.

mac35_npix (35, spectral rows) = no of pixels in that macropixel
mac35_pixloc (35, spectral rows, 20, 2) =
35 = macro pixel in the spatial direction
Spectral row = macro pixel in the spectral dimension

20 = 1- macro_npix for that pixel; that is 1 for each pixel making up the macropixel
4th dimension: 1= spatial full CCD coordinate for the pixel making up the macropixel in CVO coordinates;
2 = spectral full CCD coordinate for the pixel making up the macropixel in CVO coordinates.