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Joint Polar Satellite System Algorithm Specification Volume III: Operational Algorithm Description (OAD) for the OMPS Total Column RDR/SDR

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Joint Polar Satellite System
Algorithm Specification Volume III:
Operational Algorithm Description (OAD) for the OMPS Total Column RDR/SDR

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Preface

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

Any questions should be addressed to:

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Change History Log

Revision	Effective Date	Description of Changes (Reference the CCR & CCB/ERB Approval Date)
Rev -	Aug 08, 2013	This was approved by the JPSS Ground ERB via **474-CCR-13-1117** on the effective date shown.
Rev -1	Oct 23, 2014	This version incorporates **474-CCR-14-2094** which was approved by JPSS Ground ERB on the effective date shown. This version was baselined in support of Change Order 10.
Rev -1 - Revalidated	Dec 11, 2019	The expiration date on this document has been extended five years by 474-CCR-19-4789, which was approved by the JPSS Ground AERB on Dec 11, 2019. The effective date and the revision/version on this document will remain the same, only the expiration date has been changed.
Rev A	Aug 09, 2023	This version incorporates 474-CCR-23-6516 which was approved by the Ground ERB on May 01, 2023 and the Ground CCB on May 24, 2023 and 474-CCR-23-6461 which was approved by the Ground Segment ERB on Aug 04, 2023 and by the JPSS Ground Segment CCB on the effective date shown.

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1 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 Joint Polar Satellite System (JPSS) 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 OAD provides a software description of that science as implemented in the operational ground system.

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. 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.

2 RELATED DOCUMENTATION

The latest JPSS document(s) can be obtained from URL: https://jpssmis.gsfc.nasa.gov/frontmenu_dsp.cfm. JPSS Project documents have a document number starting with 470, 472 or 474 indicating the governing Configuration Control Board (CCB) (Program, Flight, or Ground) that has the control authority of the document.

2.1 Parent Documents

The following reference document is the Parent Document from which this document has been derived. Any modification to a Parent Document will be reviewed to identify the impact upon this document. In the event of a conflict between a Parent Document and the content of this document, the JPSS Program CCB has the final authority for conflict resolution.

Document Number	Title
474-00448-01-04	JPSS Algorithm Specification Volume I: SRS for the OMPS Total Column RDR/SDR

2.2 Applicable Documents

The following documents are the Applicable Documents from which this document has been derived. Any modification to an Applicable Document will be reviewed to identify the impact upon this document. In the event of conflict between an Applicable Document and the content of this document, the JPSS Program CCB has the final authority for conflict resolution.

Document Number	Title
429-05-02-42	NPP Mission Data Format Control Book (MDFCB)
429-05-02-42-02	NPP MDFCB Appendix A
472-00251	Mission Data Format Control Book (MDFCB) Joint Polar Satellite System-1 (JPSS-1)
474-00448-02-04	JPSS Algorithm Specification Volume II: Data Dictionary for the OMPS Total Column RDR/SDR

3 ALGORITHM OVERVIEW

This document is the operational algorithm description for the TC SDR algorithm. The processing relationship between RDRs, SDRs and the TC EDR is illustrated in Figure 3-1. NOTE: The Calibration flow has been removed from IDPS and is processed in GRAVITE.

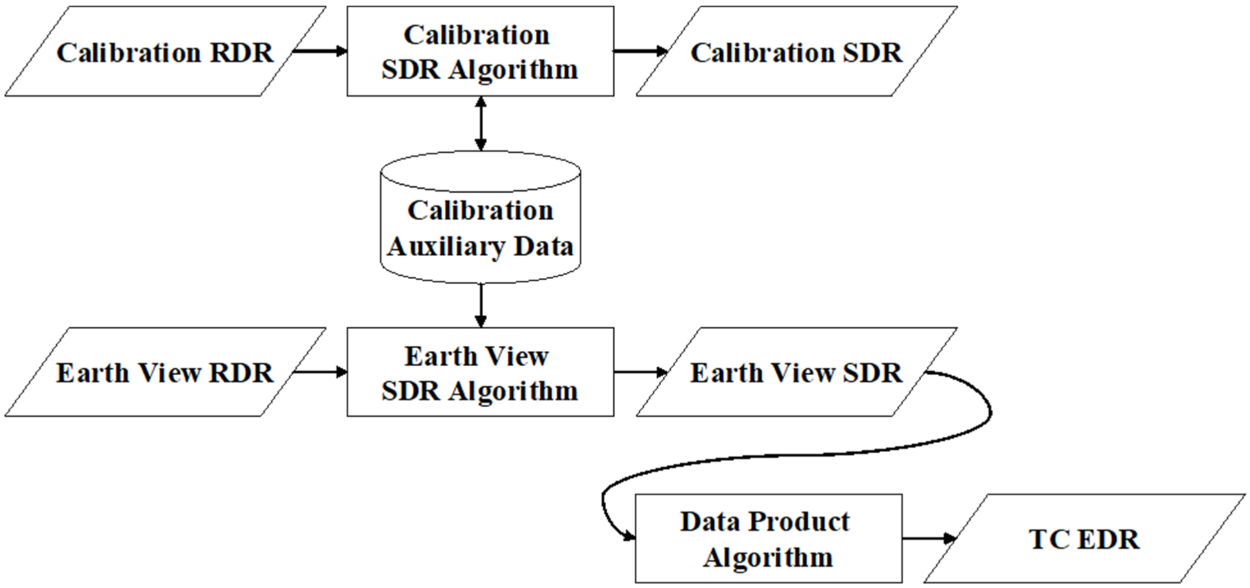


Figure 3-1: Processing Chain Associated with the OMPS TC Ozone

3.1 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 done off-line in GRAVITE. 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.

3.1.1 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 Earth View SDR algorithm is shown in Figure 3.1.1-1. 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 quaternion libraries are used for geolocation and calculation of observing angles. These libraries are compiled separately from the TC SDR algorithm and are linked to the TC SDR algorithm as a library.
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.

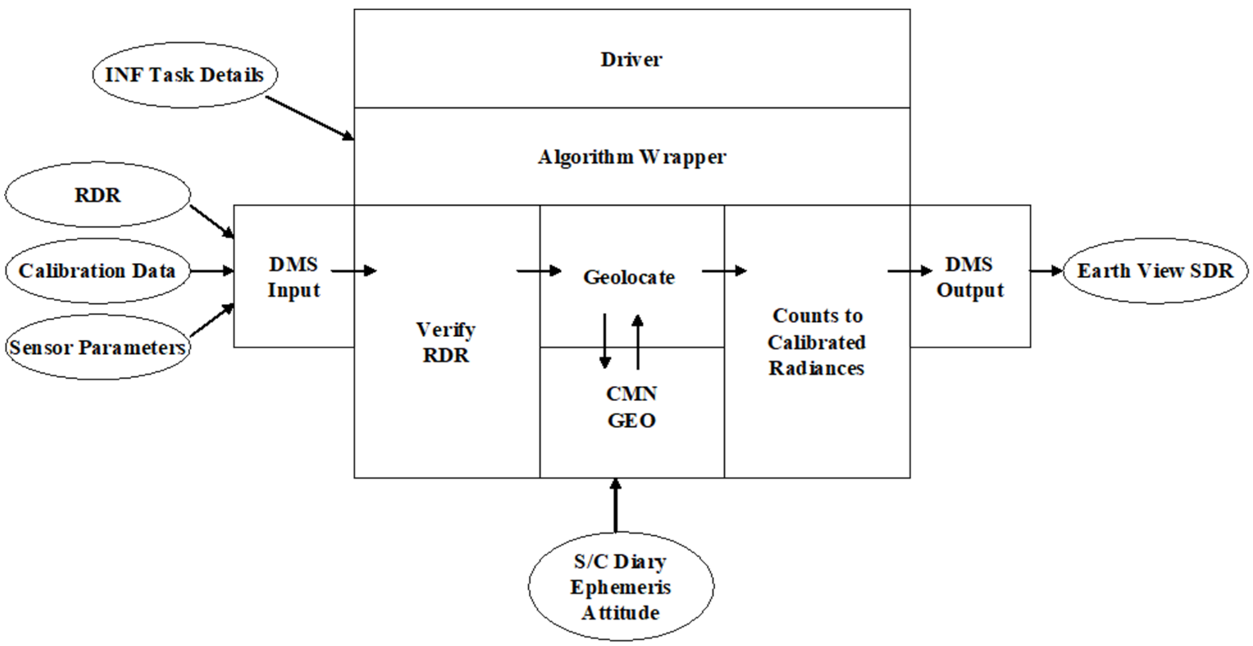


Figure 3.1.1-1. Earth View SDR Processing Schematic

For Flight Software 6.0 compressed data, a decompressor subroutine needs to be run before the verified RDR. The architecture and the schematic of the processing are indicated in Figure Figure 3.1.1-2 and Figure Figure 3.1.1-3.

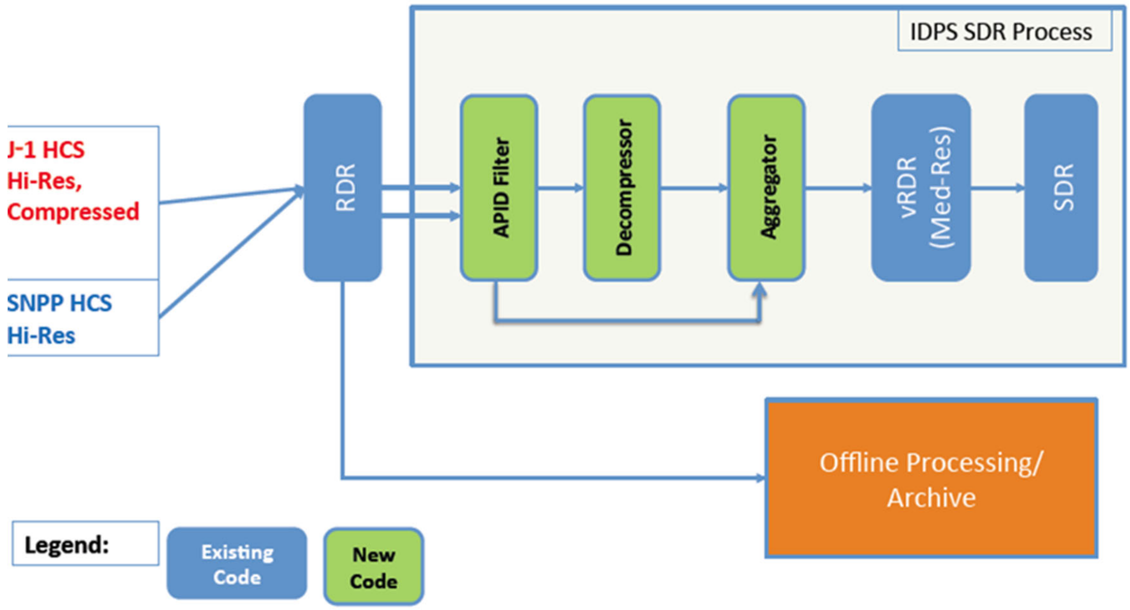


Figure 3.1.1-2. SDR Process

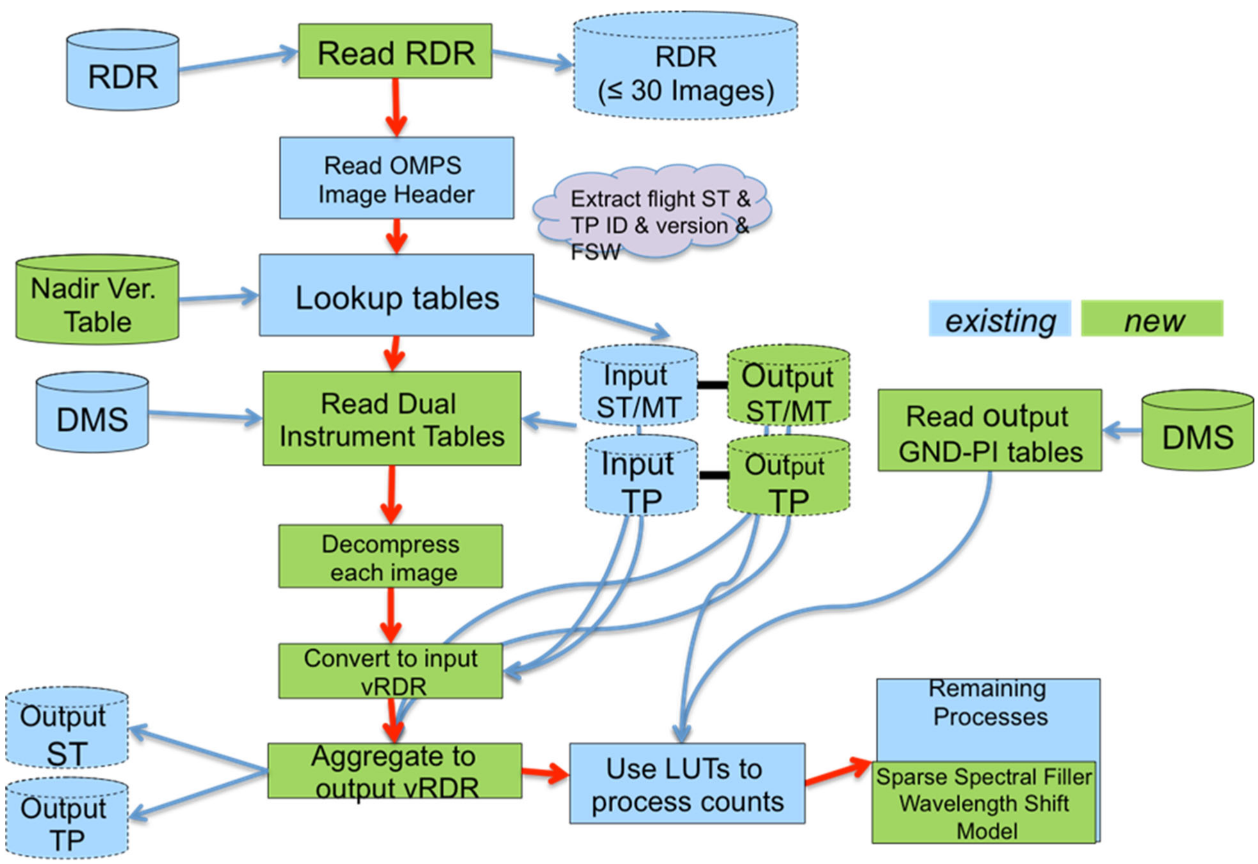


Figure 3.1.1-3. OMPS Pro SDR Flow

In order to process J01 high resolution data, a spatial and a temporal re-aggregator have been inserted before the output vRDR (see Figures 3.1.1-2, 3.1.1-3, and 3.1.1-4).

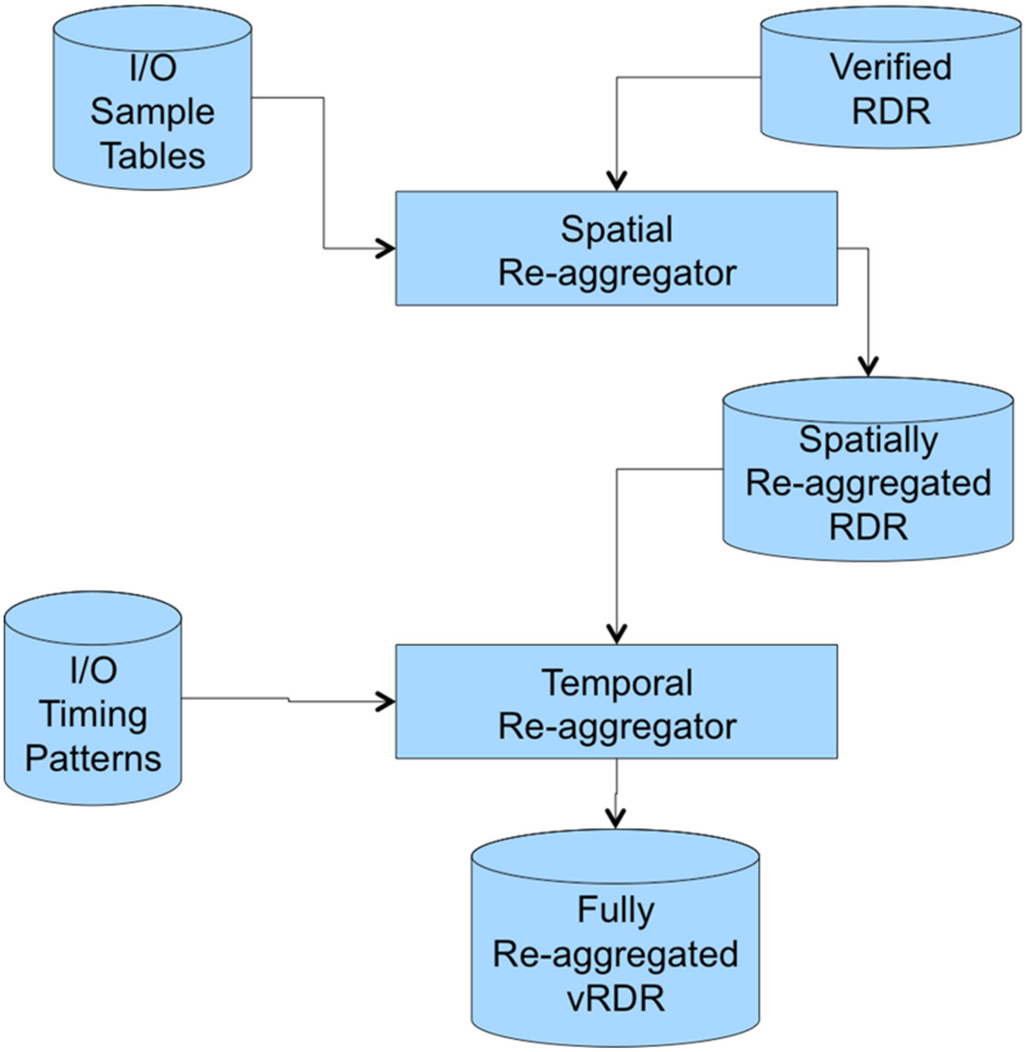
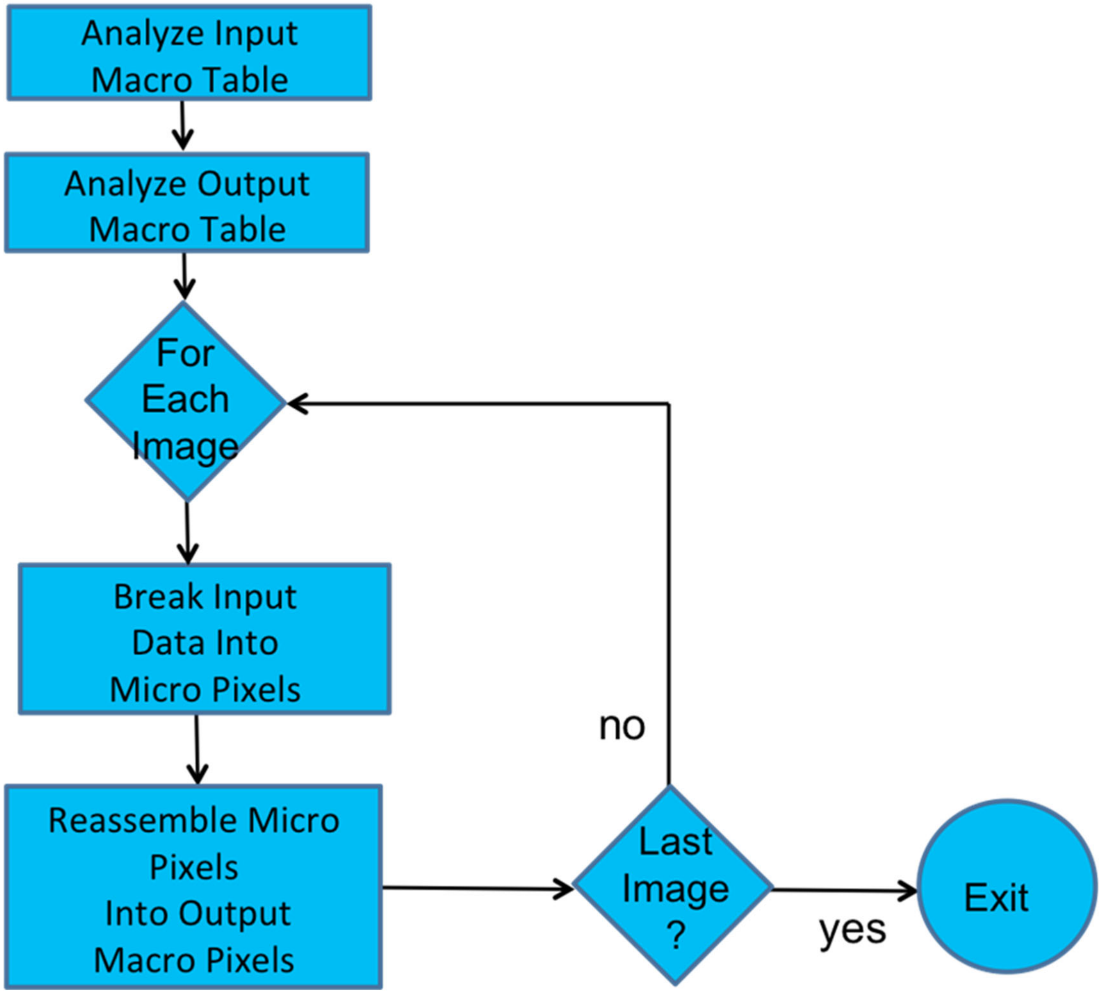
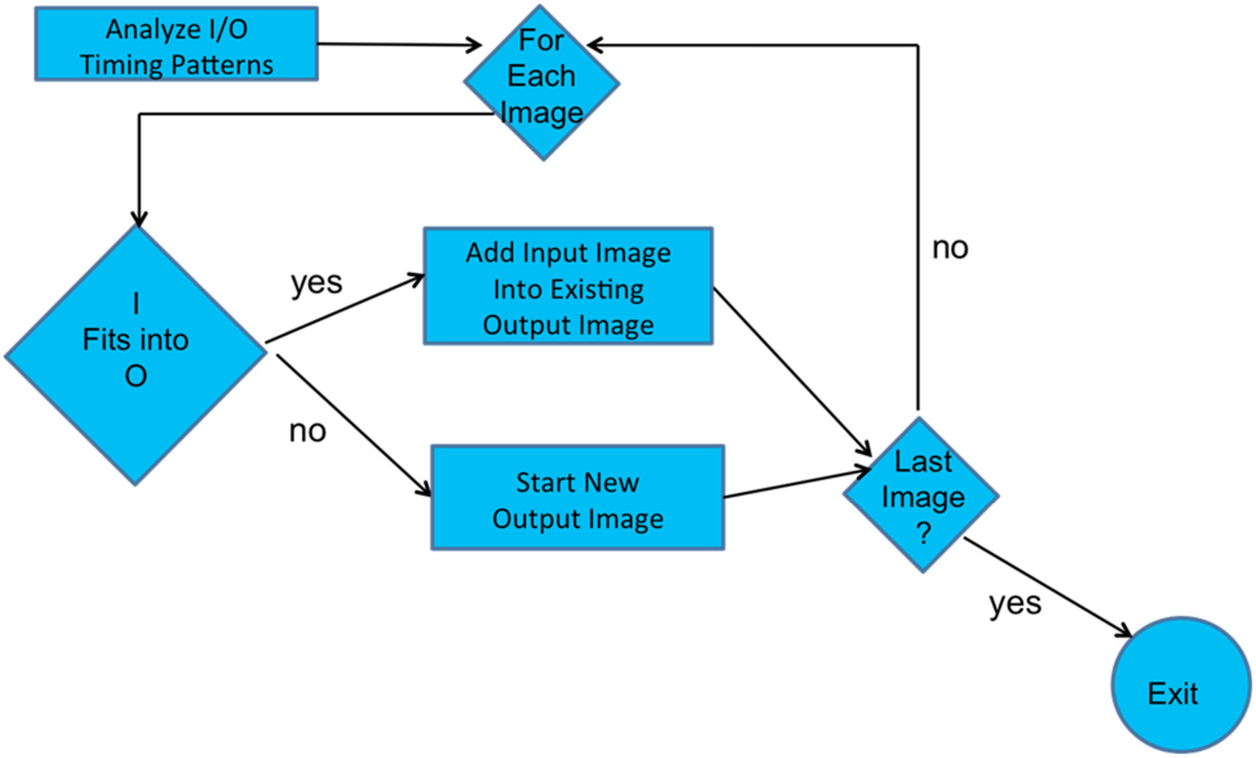


Figure 3.1.1-4. Verified RDR Aggregator

The aggregator subroutines require dual-sized GND-PIs (sample table, macro table and timing pattern): Medium or High resolution half of the LUT to describe the input to the aggregator and a Low resolution half of the LUT to describe the output of the aggregation. The Low resolution half of the LUT is used for the input to the standard SDR. See **Error! Reference source not found.** and **Error! Reference source not found.** for the schematic of the spatial and temporal aggregator.



Error! Reference source not found.. **Spatial Re-aggregator**



Error! Reference source not found.. **Temporal Aggregator**

3.1.1.1 Earth View SDR Inputs

The Earth View algorithm uses a number of inputs as listed in Table 3.1.1.1-1. Each input is listed as a separate entry in this table and are described in more detail in the sections below. In the table and sections below, "Ground ISF" refers to Ground Integrated Support Facility.

Table 3.1.1.1-1. OMPS Total Column SDR Inputs

Input Data	Description	Reference Document
Biases	Electronics bias value for 1st and 2nd CCD image halves.	474-00448-02-04_JPSS-DD-Vol-II-Part-04
Calibration Constants	Radiometric sensitivities for the full CCD; one set each for primary and redundant electronics.	474-00448-02-04_JPSS-DD-Vol-II-Part-4
Darks	Darks PC table contains averaged detector dark signal in linearity corrected counts (the average of the dark frames during a specific calibration event).	474-00448-02-04_JPSS-DD-Vol-II-Part-4
SAA Darks	SAA Darks PC table contains detected dark signal in linear corrected counts during South Atlantic Anomaly.	474-00448-02-04_JPSS-DD-Vol-II-Part-4
Field Angles Map	Pre-launch angles map containing cross-track and along-track view angles.	474-00448-02-04_JPSS-DD-Vol-II-Part-4
Observed Solar	Baseline OMPS observed reference solar irradiances and solar counts.	474-00448-02-04_JPSS-DD-Vol-II-Part-4
Wavelengths	Ground ISF Approved Wavelengths	474-00448-02-04_JPSS-DD-Vol-II-Part-4

Input Data	Description	Reference Document
Earth View Sample Table	Ground ISF Approved Earth View Sample Table. See below for a detailed description.	474-00448-02-04_JPSS-DD-Vol-II-Part-4
Macropixel Sample Table	Ground ISF Approved Macropixel Table. See below for a detailed description.	474-00448-02-04_JPSS-DD-Vol-II-Part-4
Timing Pattern Table	Ground ISF Approved Timing Pattern Table. See below for a detailed description.	474-00448-02-04_JPSS-DD-Vol-II-Part-4
Calibration Coefficients	The Ephemeral PC provides tunable processing coefficients.	474-00448-02-04_JPSS-DD-Vol-II-Part-4
OMPS Table Version Lookup Table	Contains information to track table and version identification of several OMPS TC tables.	474-00448-02-04_JPSS-DD-Vol-II-Part-4
Calibration Factors	Ground ISF Approved Radiometric Calibration Factors - Earth	474-00448-02-04_JPSS-DD-Vol-II-Part-4
Stray Light Correction LUT	Stray Light coefficients used in corrections by the OMPS TC Earthview SDR.	474-00448-02-04_JPSS-DD-Vol-II-Part-4
Surface Type LUT	Global surface type table used for sun glint computation	474-00448-02-04_JPSS-DD-Vol-II-Part-4
OMPS TC Science RDR	Total Column Earth View RDR. See also Section 3.1.1.1.1 for a more detailed description.	474-00448-02-04_JPSS-DD-Vol-II-Part-4
Spacecraft Diary RDR	Spacecraft Attitude and Ephemeris information.	474-00448-02-08_JPSS-DD-Vol-II-Part-8

3.1.1.1.1 RDR Input

The SRS 474-00448-02-04_JPSS-DD-Vol-II-Part-4 contains the RDR input parameters assumed by the SDR algorithm for the Total Column Earth View RDR (e.g., APID 560). The size of the radiance data block stored in each RDR depends on which type of RDR it is: compressed/uncompressed or medium/low resolution. For images that are less than full frame, the quantity of radiance data can be determined by consulting the appropriate sample table for that image type.

Appendix A 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.

3.1.1.1.2 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 3.1.1.1-1 for format details.

3.1.1.1.3 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. The LUT has 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. See Table 3.1.1.1-1 for format details.

3.1.1.1.4 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.

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 3.1.1.1-1 for the format of the Table Versions Lookup Table.

3.1.1.1.5 Ground ISF Approved 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.

3.1.1.1.6 Ground ISF Approved 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.

3.1.1.1.7 Ground ISF Approved 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, however, only the Earth times are used in the Earth View SDR processing.

3.1.1.2 Earth View SDR Outputs

Earth view SDRs are discussed in Section 3.1.1.2.1, calibration databases in Section 3.1.1.2.3 and uplink files in Section 3.1.1.2.4.

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

Table 3.1.1.2-1. Earth View Outputs

Output Data	Description	Reference Document
OMPS TC SDR	OMPS Total Column Earth View SDR	474-00448-02-04_JPSS-DD-Vol-II-Part-4
OMPS TC GEO	OMPS Total Column Earth View Geolocation	474-00448-02-04_JPSS-DD-Vol-II-Part-4

3.1.2 Algorithm Processing

The Earth View SDR algorithm processes an individual granule at a time. After verifying the RDR, the number of macropixels is verified to prevent degradation in the operational environment. The number of macropixels are totaled and individually compared to the prescribed configuration in the Macropixel Table. If the quantities match, processing continues. If the quantities do not match, the task is rejected and an SDR_FAIL 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 Earth View SDR algorithm safely assumes that it only needs to process raw Earth View data since the ING SI has conveniently only allowed data received under APID 560 to be stored as OMPS TC Science RDRs.

When processing a granule of OMPS data, 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 data 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 in IDPS; the other is run in the GRAVITE environment and exclusively processes Calibration RDRs. High level modules have been specialized for each of these executables; however, the calibration only modules have been removed from IDPS and only shared modules still usable by the Earth View executable remain. Section 3.1.2.2 and its subsections detail the specialized Earth View processing. 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 Earth View Sample Table is a map of which pixels were used in the Earth View 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.

3.1.2.1 Earth View Main Science Module - tc_pipeline_earth.f90

The **tc_pipeline_earth.f90** function represents the interface between the algorithm wrapper and the science processing. This function calls a series of subroutines (**Get_evtable.f90, Get_macrotable.f90,** and **Get_timetable.f90**) 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.f90** 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.f90** to gather both engineering and raw CCD data from the verified RDR. Finally, this function calls **tc_process_pipe.f90** to perform the science processing for an Earth View RDR.

3.1.2.1.1 Subroutine tc_process_pipe_earth.f90

Subroutine **tc_process_pipe_earth.f90** continues the setup and initialization process before calling **tc_earth_view_earth.f90**. The solar reference spectrum is gathered by **Read_spec.f90**. Then wavelengths are gathered in **Band_center_read.f90**. The **tc_earth_view_earth.f90** subroutine is a major module that is described in its own section below.
tc_process_pipe_earth.f90 calls **Get_instrum_params**, **Read_spec_earth**, **Band_center_read**, **Flag_waves**, **tc_earth_view_earth** and is called by **tc_pipeline_earth**.

3.1.2.1.2 Decompressor subroutine OmpsDecompress

The getDataItemssubroutine calls the readAPs subroutine in the OMPS Verified RDR convertor to call the decompression subroutine OmpsDecompress (implements Rice decompression assuming compression parameters described in BATC compression document). This subroutine calls the Rice decompression subroutine: SZ_BufftoBuffDecompress. The Rice decompression library is available by way of the szip-2.1 COTS. No additional libraries need to be used. The Rice algorithm is a lossless decompression algorithm and is recommended in CCSDS standards.

The data to decompress is copied to an array and several parameters are set. The subroutine call in c is:

status = SZ_BufftoBuffDecompress((void*)decompressed_output, &output_size, (void*)compressedbuffer, nbytes_compressed, parameters_struct);

3.1.2.1.3 Aggregator subroutines in ProSdrOmpsTcEarth

The doProcessing subroutine calls the createVerifiedRdr subroutine to finalize the conversion of a Raw (unaligned) RDR into the Verified (byte aligned) RDR. This subroutine contains a C++ interface to the Fortran 90 implementation in J0_aggr_f.f90. The createVerifiedRdr subroutine first determines the number of macropixels in the input half of the macropixel table and calls the convertVRDR subroutine in the OMPS Verified RDR convertor to finalize the image swaths and validate the number of macropixels in each image. Next, the createVerifiedRdr subroutine calls the two Fortran 90 functions: tcreaggrspatial and tcreaggrtemporal.

3.1.2.1.4 Aggregator functions tcreaggrspatial and tcreaggrtemporal

The J0_aggr_f.f90 Fortran module implements the two functions: tcreaggrspatial and tcreaggrtemporal. These functions are used to change from the on-board spatial and temporal aggregation to a desired set of aggregation as input to the SDR.

- A verified RDR as measured by the instrument and its associated sample table and time pattern are collected
- The desired output sample table and time pattern are provided
- The input sample patter is used with simple averaging to generate counts at the pixel level from each macropixel. A count value of C collected over N pixels becomes a set of C/N count values for all the associated pixels

De-aggregation:

- The counts C(i,j) are reapportioned to spatial pixels, i, by simple average
- The output sample table is used to re-aggregate the counts for the appropriate pixels to create the macropixel count values

Re-aggregation

- The counts are re-aggregated to new spatial macropixels for each FOV by simple sums
- If measurements for a wavelength row are not present in the input sample table but are in the output sample table, then zero count values are entered for the macropixels for that wavelength.

The temporal code component of the aggregator checks to determine whether the current input image falls with the output image interval from the output timing pattern table. If it does, the counts are added to the existing image. If not, a new output image is started and they are added to its values. After the last image the process is complete.

3.1.2.1.5 Subroutine RDF_input_earth.f90

RDF_input.f90 is called once per tasking, accepting a verified RDR as its input. It then extracts RDR Command & Telemetry header data and raw Earth View CCD data. This subroutine also checks limits on all the RDR data.

read_RDR_hdr_earth.f90 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.f90** and radiances stored in array *raw_data* are transferred to Earth storage arrays. The **fill_limits_flags.f90** subroutine stores limits flags set in **rdr_limits.f90** 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.

3.1.2.1.6 Subroutine Read_spec_earth.f90

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

3.1.2.1.7 Subroutine tc_earth_view_earth.f90

A major branch of the SDR Algorithm is the processing of Earth view data. The routine **tc_earth_view_earth.f90** starts with some initialization for stray light. Then it continues by calling **Get_bias.f90** to collect bias data from the Biases auxiliary input to be used in subtracting from all Earth view data by **sub_bias_earth.f90**. Next, the dark data is collected and subtracted from the Earth view data by **sub_dark_earth.f90,** and the smear data is calculated and removed by **subtract_smear_earth.f90**. If the stray light correction flag is turned on, stray light correction is performed.

Prior to the stray light correction, code is executed to correct for sparse spectral data sets. The code checks the measured rows for uncorrected raw counts that have non-zero entries. The results are the number of rows of spectral measurements, M, with their indices m1 to mM. The code uses the Solar Spectra to create a full set of counts for all wavelengths by using interpolation of the relative corrected counts to solar irradiance ratios. The interpolated values are converted back into counts for the missing wavelengths.

Calibration factors applicable for the day of the observations are selected by **Read_cal_factors_tc.f90**. The reference solar spectrum is input by **Read_solar_ref.f90**, 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, **InsertSdrDms_earth.f90** stores the Earth radiances within the Earth view SDR in shared memory.

The bias, dark, and smear corrections are discussed in TC, Section 3.1.2.6. The stray light correction is discussed in TC, Section 3.1.2.7. The radiometric correction is presented in TC, Section 3.1.2.8. Mapping of the signal and radiometric corrections to the following subroutines is straightforward.

3.1.2.1.8 Subroutine Get_evtable.f90

Get_evtable.f90 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_earth**.

3.1.2.1.9 Subroutine Get_macrotable.f90

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 Array Dimensions and Coordinate Systems for description). It is called by **tc_pipeline_earth**.

3.1.2.1.10 Subroutine Get_timetable.f90

Get_timetable.f90 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_earth**.

3.1.2.1.11 Subroutine Get_instrum_params.f90

Get_instrum_params.f90 inputs a series of sensor parameters. Next, data in the radiance calibration constantsinput is ingested into the processing environment by the subroutine **Read_resp.f90**, and stored in array *radevresp* (used with *resp_piece* to calculate the *cal* variable in **tc_earth_view.f90** subroutine. 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_prof*, *offsetw*, and *wavefunc* arrays. It is called by **tc_pipeline_earth.**

3.1.2.1.12 Subroutine Read_wave_ref.f90
This subroutine uses values from the Spectral Registration Pixel Map LUT to store in array *wmap*. It is called by **Get_instrum_params**.

3.1.2.1.13 Subroutine Read_resp.f90
This subroutine reads in the radiance calibration constants, converts the data from Full Array coordinates to CVO coordinates (using **FullCCD2viewonly.f90**), and removes any bad pixels. It calls **FullCCD2viewonly.f90** and is called by **Get_instrum_params**.

3.1.2.1.14 Subroutine FullCCD2viewonly.f90
This subroutine will convert data from Full Array coordinates to CVO coordinates. It is called by **Read_resp**, and **Read_solar_ref**.

3.1.2.1.15 Subroutine read_RDR_hdr_earth.f90
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.

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_earth**.

3.1.2.1.16 Subroutine rdr_limits.f90
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_earth**.

3.1.2.1.17 Subroutine save_rdr_hdrs.f90
This subroutine transfers header variables into storage arrays by data type (EARTH, DARK, LAMP or, SOLAR). It is called by **RDF_input_earth**.

3.1.2.1.18 Subroutine fill_limit_flags.f90
This subroutine transfers limits flags into storage arrays by data type (EARTH, DARK, LAMP or, SOLAR). It is called by **RDF_input_earth**.

3.1.2.1.19 Subroutine Band_center_read.f90
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_earth**.

3.1.2.1.20 Subroutine Flag_waves.f90

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**.

3.1.2.1.21 Subroutine Stats4.f90

Subroutine **Stats4** computes median, mean, standard deviation, min and max values of real*4 array x of n elements. **Stats4** calls maxmedmin and is called by **Flag_waves**, **StatsCWS2mac37**, and **tc_earth_view_earth**.

3.1.2.1.22 Subroutine maxmedmin.f90

Subroutine **maxmedmin** computes the maximum, minimum, and median of an array. This subroutine was written to replace the use of subroutines from Numerical Recipes. This module also implements the routines SELECT and PARTITION from Horowitz and Sahni (1978), Fundamentals of Computer Algorithms.

3.1.2.1.23 Subroutine Get_bias.f90

Get_bias collects the most recent value for each side of the CCD from the Biases auxiliary input. **Get_bias** is called by **tc_earth_view_earth**.

3.1.2.1.24 Subroutine read_dark.f90

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**.

3.1.2.1.25 Subroutine Read_solar_ref.f90

Subroutine **Read_solar_ref** gets the Day 1 Reference Solar Flux (rsf) from the Observed Solar LUT and reformats the data using **FullCCD2viewonly.f90**. **Read_solar_ref** calls **FULLCCD2viewonly** and is called by **tc_earth_view_earth**.

3.1.2.1.26 Subroutine interpolate.f90

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

3.1.2.1.27 Subroutine AvgCVO2mac35.f90

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.

3.1.2.1.28 Subroutine sub_bias_earth.f90

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.

3.1.2.1.29 Subroutine sub_dark_earth.f90

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.

3.1.2.1.30 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.

3.1.2.1.31 Subroutine Read_SAA_dark.f90

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

3.1.2.1.32 Subroutine subtract_smear_earth.f90

This subroutine calculates 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.

3.1.2.1.33 Subroutine Read_cal_factors_tc.f90

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

3.1.2.1.34 Subroutine InsertSdrDms_earth.f90

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

3.1.2.1.35 Subroutine sol_wscale_shift.f90

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. Two methods are used to identify and adjust the wavelength scale and solar spectra.

1. Uses fits for the radiances for each granue to estimate the cross-track dependent shifts.
2. The intra-orbit wavelength shifts are estimated by using a cubic polynomial. It uses estimates from cubic fits of the wavelength shifts versus solar zenith angle. The model parameter for fits are appended to the existing wavelength GND-PI tables and read in at the same time as the wavelength scales.

A parameter, rsf_pw_limit, limits the absolute value of the wavelength shifts and also is used as the flag to determine the wavelength scale method (<=0 use the measurement-based method; >0 use the model)

After using one of the two methods to calculate an estimate for the shift, the estimate is combined with an expected solar shift pattern to create a new solar spectrum adjusted to the new earth-view wavelength scale. The adjusted wavelength scale, the new solar to match this adjusted earth-view scale and the estimated shift are all reported in the SDR.

3.1.2.1.36 Subroutine smear_correct_tc.f90

This subroutine detects and corrects for transient values in the smear pixels. This is done by removing outliers and noise. Outliers are greater than max_threshold and are replaced with the median value of the smear counts. Noise is smoothed by using a least squares cubic polynomial fit and replacing values exceeding min_threshold by the fit value. The least squares fit is repeated on values less than min_threshold which are replaced with the fit value. This subroutine accounts for the differences in the smear structure between the S-NPP and J01 (NOAA-20) spacecraft. This method is used in both the OMPS-TC and OMPS-NP to remove outliers from the smear pixel measurements.

3.1.2.1.37 Subroutine lfit.f90

This subroutine computes the least squares cubic polynomial fit for smear transient correction in smear_correct_tc.f90. It is also used in sol_wscale_shift.f90.

3.1.3 Graceful Degradation

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

3.1.3.1 Graceful Degradation Inputs

None.

3.1.3.2 Graceful Degradation Processing

None.

3.1.3.3 Graceful Degradation Outputs

None.

3.1.4 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 off-line in GRAVITE and are excluded from calculations only after being approved by the Ground ISF. The identification of long term bad pixels currently relies only on off-line processing of 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.

3.1.5 Data Quality Monitoring

None.

3.1.6 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 a few subroutines.

3.1.7 Algorithm Support Considerations

None.

3.1.8 Assumptions and Limitations

3.1.8.1 Assumptions

All necessary data is available and provided within the necessary time constraints.

3.1.8.2 Limitations

None have been identified at this time.

4 GLOSSARY/ACRONYM LIST

4.1 Glossary

Below is a glossary of terms most applicable for this OAD.

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 Engineering Review Board (AERB)	Interdisciplinary board of scientific and engineering personnel responsible for the approval and disposition of algorithm acceptance, verification, development and testing transitions. Chaired by the Data Process Algorithm Lead, members include representatives from STAR, DPMS, IDPS, and Raytheon.
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 GRAVITE facility. Delivered code is executed on compatible GRAVITE computing platforms. Minor hosting modifications may be made to allow code execution. Optionally, verification may be performed at the Algorithm Provider's facility if warranted due to technical, schedule or cost considerations.
Ancillary Data	Any data which is not produced by the JPSS System, but which is acquired from external providers and used by the JPSS system in the production of JPSS data products.
Auxiliary Data	Auxiliary Data is defined as data, other than data included in the sensor application packets, which is produced internally by the JPSS system, and used to produce the JPSS deliverable data products.
EDR Algorithm	Scientific description and corresponding software and test data necessary to produce one or more environmental data records. The scientific computational basis for the production of each data record is described in an OAD. 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
Model Verification	The process of determining that a model implementation accurately represents the developer's conceptual description and specifications
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 JPSS (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/ JPSS data product (TDR, SDR or EDR). The former is described in an OAD. 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 Operational Algorithm Document (OAD). 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.

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

4.2 Acronyms

Below is a list of acronyms most applicable for this OAD.

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

Term	Expansion
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
CrIS	Cross-Track Infrared Sounder
CSCI	Computer Software Configured Item
CVO	Clipped View Only
CWS	Clipped With Smear
DCP	Data Collection Platforms
DES	Digital Encryption System
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

Term	Expansion
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
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

Term	Expansion
LRD	Low Rate Data
LSS	Launch Support Segment
LST	Local Solar Time
LUT	Look-up Table
LV	Launch Vehicle
MDFCB	Mission Data Format Control Book
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
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
RDR	Raw Data Records

Term	Expansion
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

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 A-1 shows the coordinate system array names and their dimensions, and Table A-2 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 A-1. 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 A-2.

Table A-2. 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 A-1. 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 A-1 and parameters in Table A-1 are calculated.

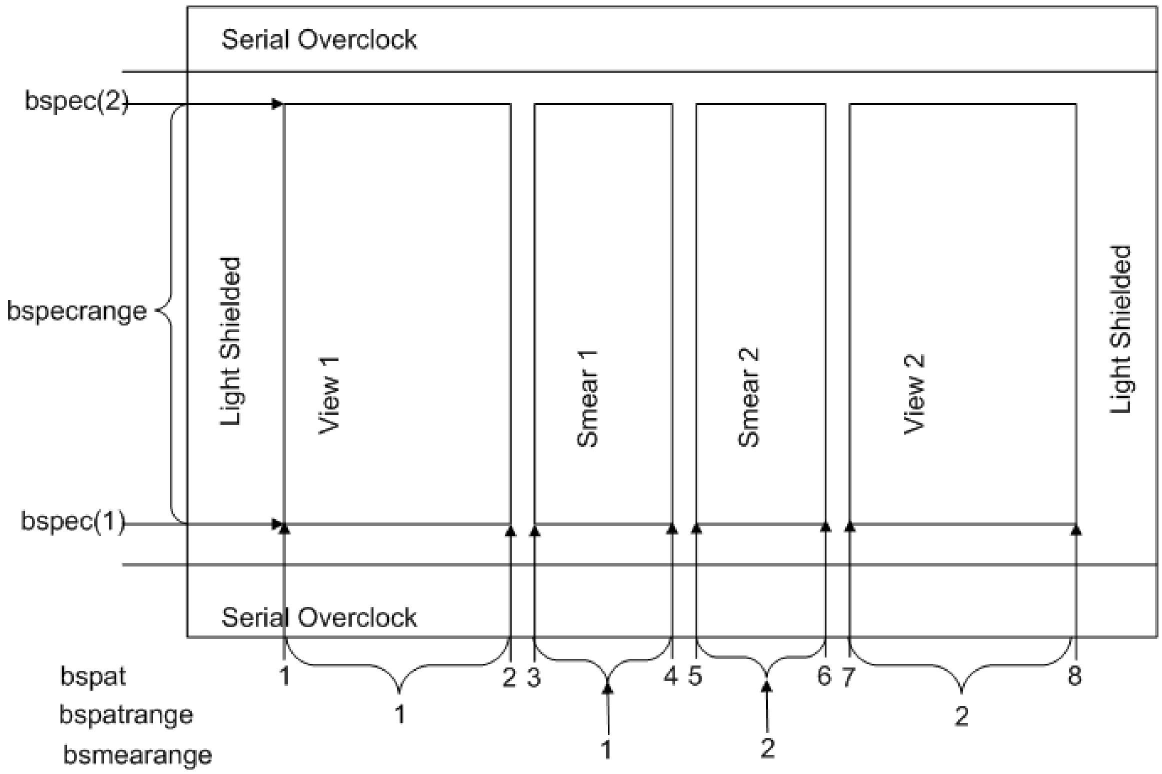


Figure A-1. Full CCD Array Coordinate System

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 A-2.

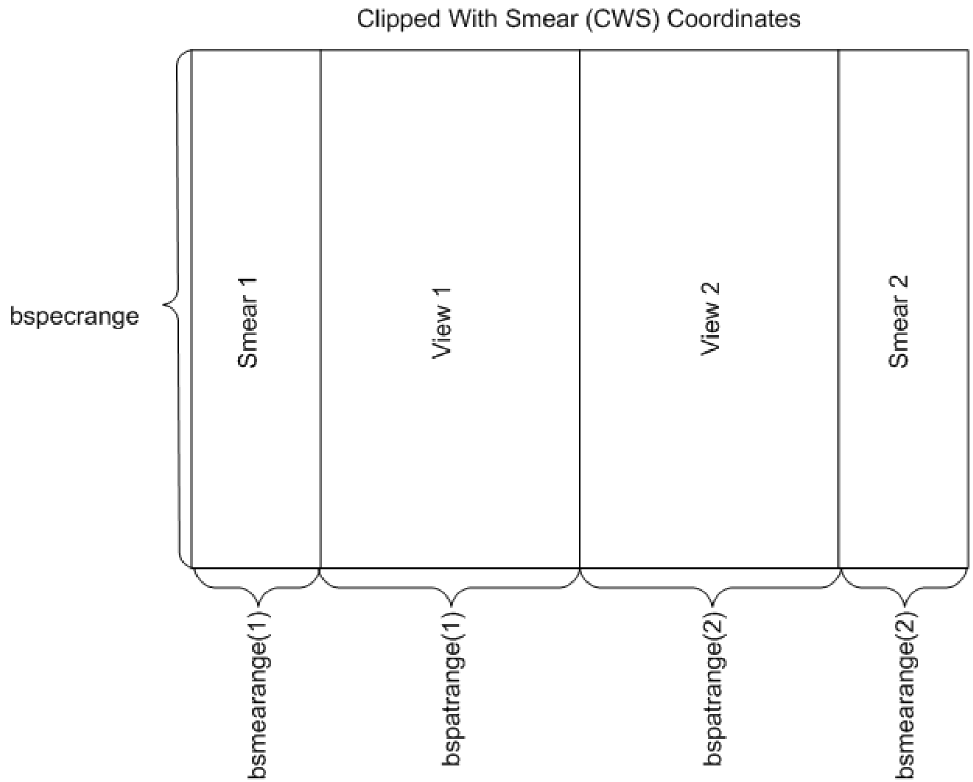


Figure A-2. Clipped with Smear Coordinate System

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 A-3. 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.

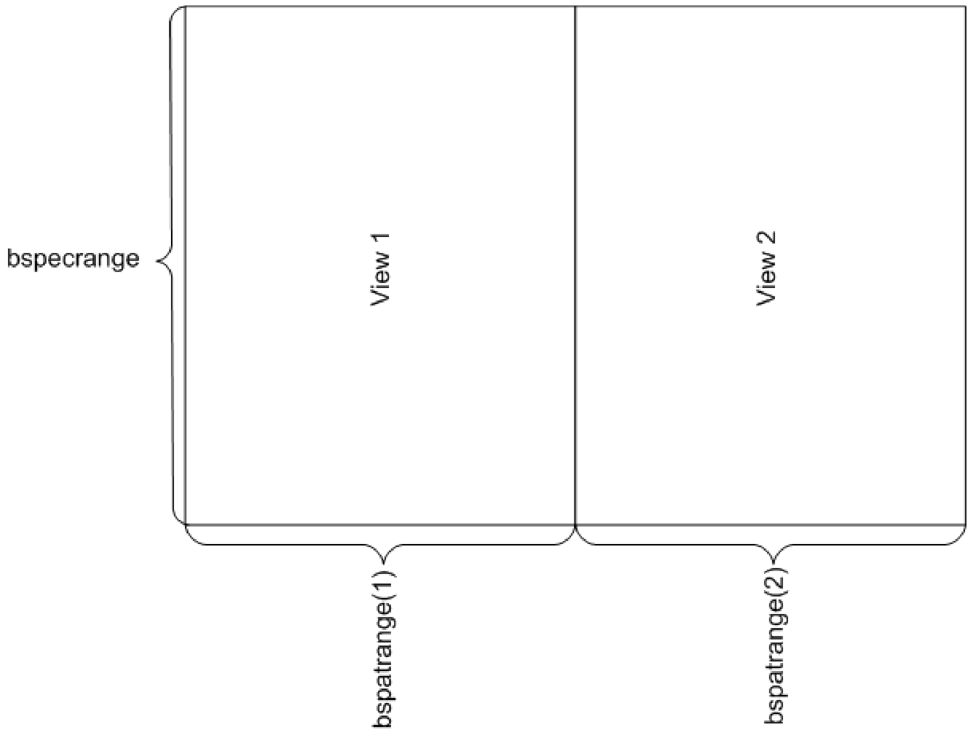


Figure A-3. Clipped View Only Coordinate System

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

4th 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 micropixel in CVO coordinates.