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

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Joint Polar Satellite System
Algorithm Specification Volume III:
Operational Algorithm Description (OAD) for the OMPS Nadir Profile 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 22, 2013	This was approved by the JPSS Ground ERB via **474-CCR-13-1124** 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 this 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. The OAD provides a software description of that science as implemented in the operational ground system.

The purpose of an OAD is two-fold:

Provide initial implementation design guidance to the operational software developer.

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. The scope of this document is limited to the description of the core operational algorithm(s) required to create the OMPS Nadir Profile (NP) SDR.

1.2 Scope

The scope of this document is limited to the description of the core operational algorithm(s) required to create the OMPS NP 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
474-00448-01-05	JPSS Algorithm Specification Volume I: SRS for the OMPS NP 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)
474-00448-02-05	JPSS Algorithm Specification Volume II: Data Dictionary for the OMPS NP RDR/SDR
474-00448-04-05	JPSS Algorithm Specification Volume IV: SRS Parameter File (SRSPF) for the OMPS RDR/SDR

3 ALGORITHM OVERVIEW

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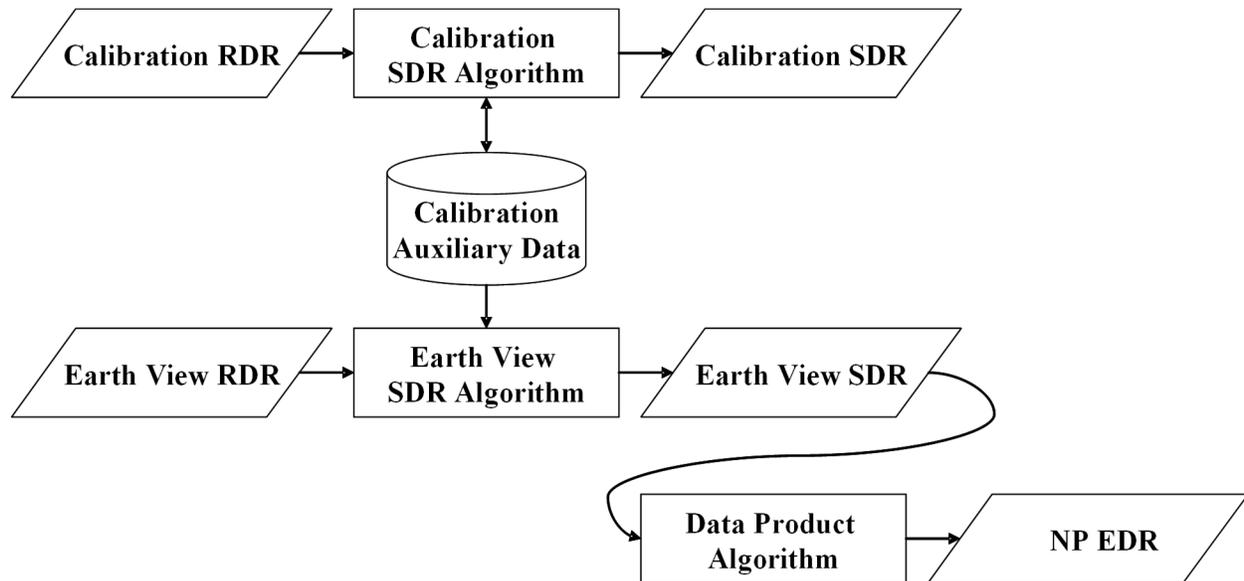
Figure 3-1. Processing Chain Associated with the OMPS NP Ozone

3.1 OMPS Nadir Profiler SDR Description

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

3.1.1 Interfaces

The NP SDR algorithm is initiated by the Infrastructure (INF) Software Item (SI) to begin processing the data. The INF SI provides tasking information to the algorithm indicating which granule is processed. The Data Management (DMS) SI provides data storage and retrieval capability. The interface to these SIs is implemented by 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 NP SDR algorithm and are linked to the NP 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.
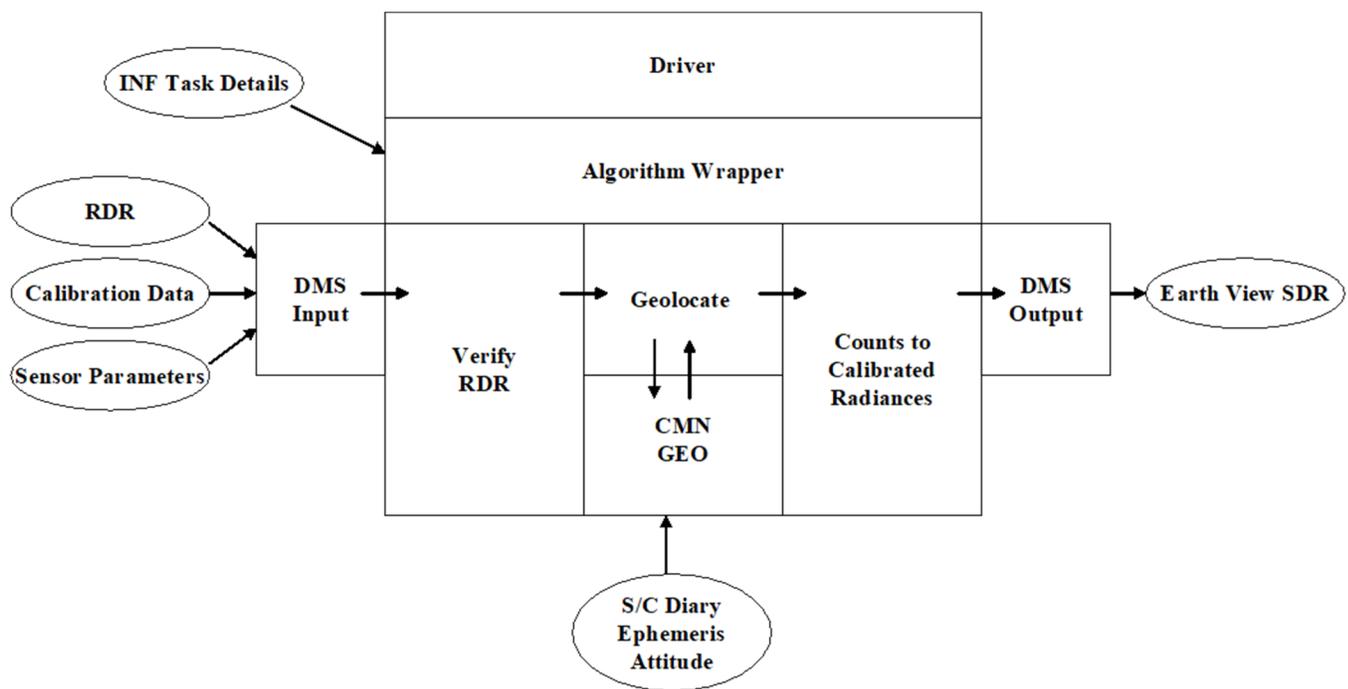
Figure 3.1.1-1. Earth View SDR Processing Schematic

3.1.1.1   Earth View 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 sections below, "Ground ISF" refers to the Ground Integrated Support Facility.

Table 3.1.1.1-1. OMPS Nadir Profile SDR Inputs

| Input	Description	Document Reference
Bias	Electronics bias value for 1st CCD image half, derived from dark data	474-00448-02-05_JPSS-DD-Vol-II-Part-05
Calibration Constants	Radiometric sensitivities for the full CCD; one set each for primary and redundant electronics.	474-00448-02-05_JPSS-DD-Vol-II-Part-5
Darks	Darks PC table contains averaged detector dark signal in linearity corrected counts (the average of the dark frames during a specific calibration event).	474-00448-02-05_JPSS-DD-Vol-II-Part-5
SAA Darks	SAA Darks PC table contains detected dark signal in linear corrected counts during South Atlantic Anomaly.	474-00448-02-05_JPSS-DD-Vol-II-Part-5
Field Angles Map	Pre-launch angles map containing cross-track and along-track view angles.	474-00448-02-05_JPSS-DD-Vol-II-Part-5
Observed Solar	Baseline OMPS observed reference solar irradiances and solar counts.	474-00448-02-05_JPSS-DD-Vol-II-Part-5
Wavelengths	Ground ISF Approved Wavelengths	474-00448-02-05_JPSS-DD-Vol-II-Part-5
Earth View Sample Table	Ground ISF Approved Earth View Sample Table. See below for a detailed description.	474-00448-02-05_JPSS-DD-Vol-II-Part-5
Macropixel Sample Table	Ground ISF Approved Macropixel Table. See below for a detailed description.	474-00448-02-05_JPSS-DD-Vol-II-Part-5
Timing Pattern Table	Ground ISF Approved Timing Pattern Table. See below for a detailed description.	474-00448-02-05_JPSS-DD-Vol-II-Part-5
Calibration Coefficients	The Ephemeral PC provides tunable processing coefficients.	474-00448-02-05_JPSS-DD-Vol-II-Part-5
OMPS Table Version Lookup Table	Contains information to track table and version identification of several OMPS TC tables.	474-00448-02-05_JPSS-DD-Vol-II-Part-5
Calibration Factors	Ground ISF Approved Radiometric Calibration Factors - Earth	474-00448-02-05_JPSS-DD-Vol-II-Part-5
Surface Type LUT	Global surface lype table used for sun glint computation	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.	474-00448-02-05_JPSS-DD-Vol-II-Part-5
OMPS TC Science RDR	Total Column Earth View RDR. See also Section 3.1.1.1.1 for a more detailed description.	474-00448-02-05_JPSS-DD-Vol-II-Part-5
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 474-00448-02-05_JPSS-DD-Vol-II-Part-5 contains the RDR input parameters assumed by the SDR algorithm for the Nadir Profiler Earth View RDR (e.g., APID 561). 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 contains additional details of coordinate systems used by the sample tables.

Figure 3.1.1.1.1-1 illustrates the radiance data storage locations expected by the SDR algorithm. The information from the sample tables will supply the specific pixel locations of the radiance data, overclock pixels and smear pixels on the full array (390x364).
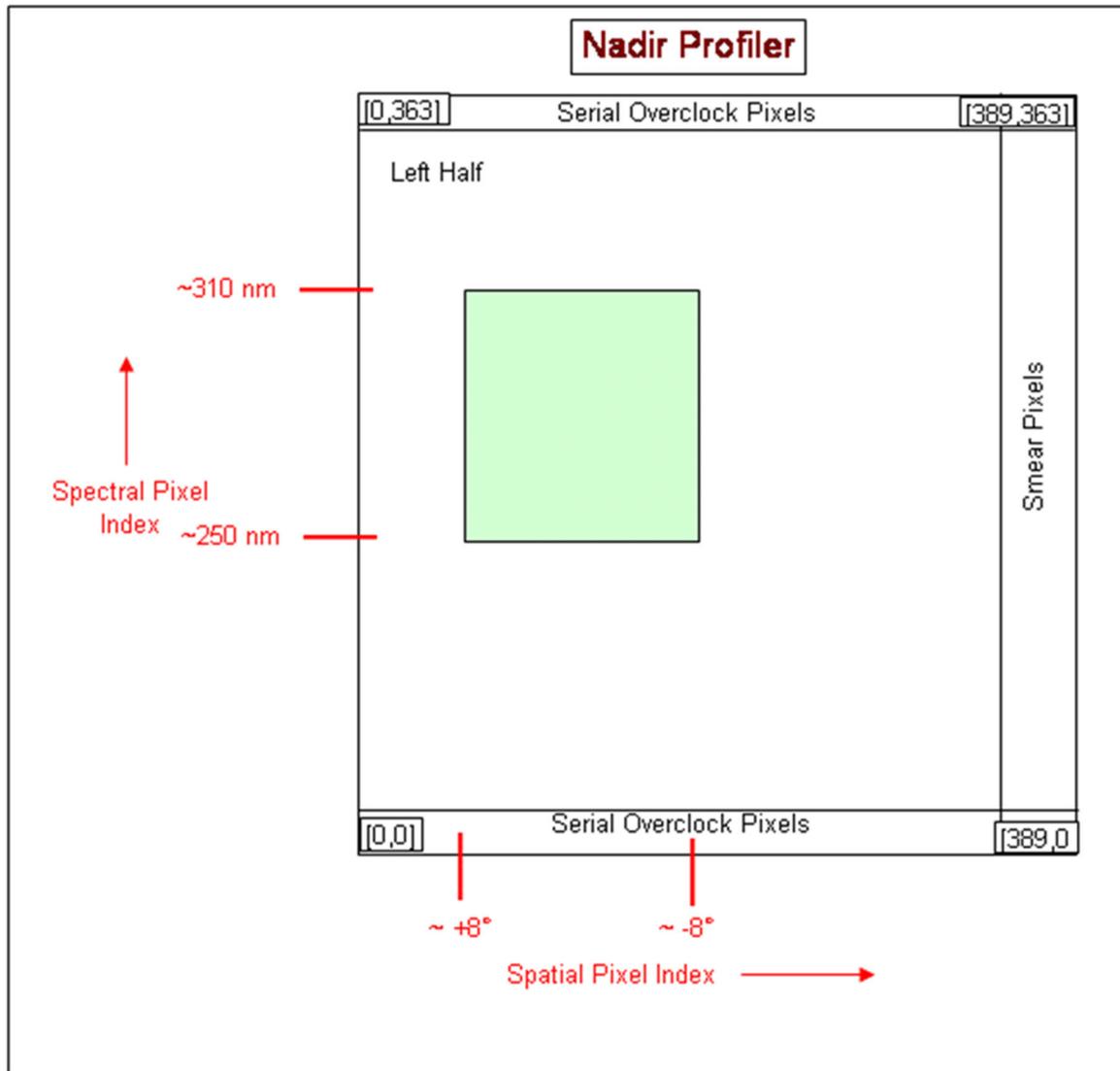
Figure 3.1.1.1.1-1. CCD Radiance Storage

3.1.1.1.2 Field Angles Map

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

RDR data. These look angles are derived from the SRG (spatial registration) database from BATC.

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.

The radiometric calibration constants are used in the np_earth_view subroutine to calculate earth radiances. This data is derived from BATC's RAD database. It contains the irradiance calibration coefficients. The data is organized into groups: one for primary electronics, the other for 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 database (sample table and bad pixel).

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 database (sample table and bad pixel).

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 database (Linearity and LED Signal).

3.1.1.2 Outputs

Earth view SDRs are discussed in Section 3.1.1.2.1, calibration databases are detailed in Section 3.1.1.2.3 and uplink files are described 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 NP SDR	OMPS Nadir Profile Earth View SDR	474-00448-02-05_JPSS-DD-Vol-II-Part-5
OMPS NP GEO	OMPS Nadir Profile Earth View Geolocation	474-00448-02-05_JPSS-DD-Vol-II-Part-5

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 561 to be stored as OMPS NP 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 2.1.2.2 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 - np_pipeline_earth.f90

The **np_pipeline_earth.f90** function represents the interface between the algorithm wrapper and the science processing. This function calls **Get_instrum_params_np.f90** to define the OMPS NP sensor parameters (CCD spatial map, CCD spectral map, and channel spectral functions). It

also calls **RDF_input_earth.f90** to input each one of the NP verified RDRs in the current granule. Finally the function calls **np_process_pipe_earth.f90** to perform the science processing for an Earth View RDR by calling **np_earth_view.f90**.

3.1.2.1.1 Subroutine np_process_pipe_earth.f90

Subroutine **np_process_pipe_earth.f90** continues the setup and initialization process before calling **np_earth_view.f90**. Then wavelengths are gathered in **Band_center_read.f90**. The **np_earth_view.f90** subroutine is a major module that is described in its own sections below. **np_process_pipe_earth.f90** calls **Get_instrum_params_np**, **Read_spec_earth**, **Band_center_read**, **Flag_waves**, **np_earth_view** and is called by **np_pipeline_earth**.

3.1.2.1.2 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 **np_pipeline_earth**.

3.1.2.1.3 Subroutine np_earth_view.f90

A major branch of the SDR Algorithm is the processing of Earth view data. The routine np_earth_view.f90 starts with some initialization for stray light. The routine **np_earth_view.f90** starts by acquiring bias data by using **Get_bias.f90**. The bias is subtracted from all Earth view data by **sub_bias_earth.f90**. Next, the dark data is read 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. For NOAA-20 OMPS-NP there is a secondary straylight correction to remove in-band straylight caused by solar intrusion. The correction only applies where the spacecraft solar zenith angle exceeds 57.5 degrees in the northern hemisphere. Calibration factors applicable for the day of the observations are selected by **Read_cal_factors_np.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 macropixels are then checked and flagged for unusually high radiances. Finally, earth radiances are stored in the Earth View SDR in shared memory.

Mapping of the signal and radiometric corrections to the following subroutines is straightforward.

3.1.2.1.4 Subroutine Get_evtable.f90

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

3.1.2.1.5 Subroutine Get_macrotable.f90

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

3.1.2.1.6 Subroutine Get_instrum_params_np.f90

Get_instrum_params.f90 inputs a series of sensor parameters. Next, data in the radiance calibration constants input 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 **np_earth_view.f90** subroutine). This subroutine also transfers values from the Spectral Registration Pixel Map LUT to the wmap array. Earth scene reference wavelengths are calculated from the *wmap* values along with min and max wavelengths. Finally, the data in the spectral response function input is used to update the *wave_pro*f, *offsetw*, and *wavefunc* arrays. It is called by **np_pipeline_earth.**

3.1.2.1.7 Subroutine Read_resp.f90

This subroutine reads in the radiance calibration constants and irradiance calibration constants, converts the data from Full Array coordinates to CVO coordinates, and removes any bad pixels. It calls no other methods, but is called by **Get_instrum_params_np.f90**.

3.1.2.1.8 Subroutine read_RDR_hdr_earth.f90

This subroutine reads the header parameters from the verified RDR and uses the header parameters to initialize program variables.

CCSDS_APID is used to specify the datatype (561=EARTH, 565=CALIB). CALIB data is ignored. Note that TC_ROWS and TC_COLS are not used.

3.1.2.1.9 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**.

3.1.2.1.10 Subroutine save_rdr_hdrs.f90

Transfer header variables into storage arrays by data type.

3.1.2.1.11 Subroutine fill_limit_flags.f90

Transfer limits flags into storage arrays by data type.

3.1.2.1.12 Function Get_instrum_params_np.f90

Get_instrum_params_np.f90 inputs a series of sensor parameters. Please see description above.

3.1.2.1.13 Subroutine Band_center_read.f90

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

3.1.2.1.14 Subroutine Flag_waves.f90

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

3.1.2.1.15 Subroutine Stats4.f90

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

3.1.2.1.16 Subroutine maxminmed.f90

Subroutine **maxminmed** 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.

3.1.2.1.17 Subroutine Get_bias.f90

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

3.1.2.1.18 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.

3.1.2.1.19 Subroutine Read_solar_ref.f90

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

3.1.2.1.20 Subroutine Interpolate.f90

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

3.1.2.1.21 Subroutine sub_bias_earth.f90

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

3.1.2.1.22 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) binning dark data at calibration resolution to Earth view macro-pixel resolution, 3) subtracting dark counts from Earth view counts. The subroutine obtains the appropriate dark from either the Darks or SAA Darks auxiliary inputs. Next, the average dark counts are calculated at Earth view macro-pixel resolution for three CCD regions: beginning smear, middle data, and ending smear columns. Finally, the locally spatially averaged macro-pixel dark signal is subtracted from the Earth view counts for each separate spatial Earth data cell.

3.1.2.1.23 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.

3.1.2.1.24 Subroutine subtract_smear_earth.f90

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

3.1.2.1.25 Subroutine smear_correct_np.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.

3.1.2.1.26 Subroutine lfit.f90

This subroutine computes the least squares cubic polynomial fit for smear transient correction in smear_correct_np.f90.

3.1.2.1.27 Subroutine Read_cal_factors_np.f90

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

3.1.2.1.28 Subroutine sdr_create_earth_idps_np.f90

Write into the DMS output buffer an IDPS formatted Earth view SDR.

3.1.3   Graceful Degradation

None.

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 NP SDR algorithm is coded to use 'real' and 'integer' declared variables for the most part. Double precision real variables are used for computational accuracy in a few subroutines.

3.1.7 Algorithm Support Considerations

None.

3.1.8 Assumptions and Limitations

3.1.8.1 Assumptions

All necessary data will be 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 JPSS, an algorithm consists of: A theoretical description (i.e., science/mathematical basis) A computer implementation description (i.e., method of solution) 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 JPSS 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 GRAVITE, is developed into operational-grade code by the IDPS IPT.

Term	Description
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
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

Term	Description
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.
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.

Acronym	Description
ADCS	Advanced Data Collection System
ARF	Anisotropic Reflectance Factor
AM&S	Algorithms, Models & Simulations
API	Application Programming Interfaces
CMN GEO	Common Geolocation
CSN	Collection Short Name
DMS	Data Management Subsystem
DQTT	Data Quality Test Table
E&A	Ephemeris and Attitude
ECEF	Earth-Centered Earth-Fixed
ECF	Earth-Centered Fixed
ECR	Earth-Centered Rotating
ECSF	Earth-Centered Space-Fixed
EES	Ellipsoid to Earth's Surface
EGM	Earth Geoid Model
EGS	Ellipsoid Geoid Separation

Acronym	Description
EPHATT	Ephemeris ad Attitude Structure
GVVSLE	Gain Value Versus Scene Lunar Elevation
GVVSSE	Gain Value Versus Scene Solar Elevation
IET	IDPS Epoch Time is the time in number of microseconds since 1-1-1958 00:00:00
IIS	Intelligence and Information Systems
INF	Infrastructure
ING	Ingest
IP	Intermediate Product
LOS	Line of Sight
LUT	Look-Up Table
MSL	Mean Sea Level
NOVAS-C	Naval Observatory Vector Astrometry System – C version
PRO	Processing
QF	Quality Flag
SAA	South Atlantic Anomaly
SDR	Sensor Data Records
SI	Software Item or International System of Units
STL	Standard Template Library
TBD	To Be Determined
TBR	To Be Resolved
TLE	Two Line Element files following the format specified by NORAD
TOA	Top of the Atmosphere
UT1	Universal Time One
UTC	Universal Time Coordinated

Appendix A   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 Profile sensor. The original assumption of a uniform data structure (all used data contained on the same 390x145 pixels on the CCD) is no longer valid, so a more flexible array sizing scheme was required.

The BATC databases give detailed information on macropixel sampling, bad pixels, solar diffuser sampling and lamp sampling. The array variations occur in both the spatial and spectral directions. In the spectral dimension, spectral smile causes the spectral size to be non-uniform. In the spatial dimension, OMPS DADD-Nadir Profile Sample Table and Bad Pixel Database (IN0092SDB-011) outlines how the macropixel sizing can vary depending on the SPATIALFLAG setting. Table A-1 shows the parameters defined from the sample table. The information is discussed in more detail in the rest of the appendix. Most of the arrays used throughout the Algorithm are initialized to the maximum possible size, and then only the "working" part of the array is used once the dimensions have been determined from the sample tables.
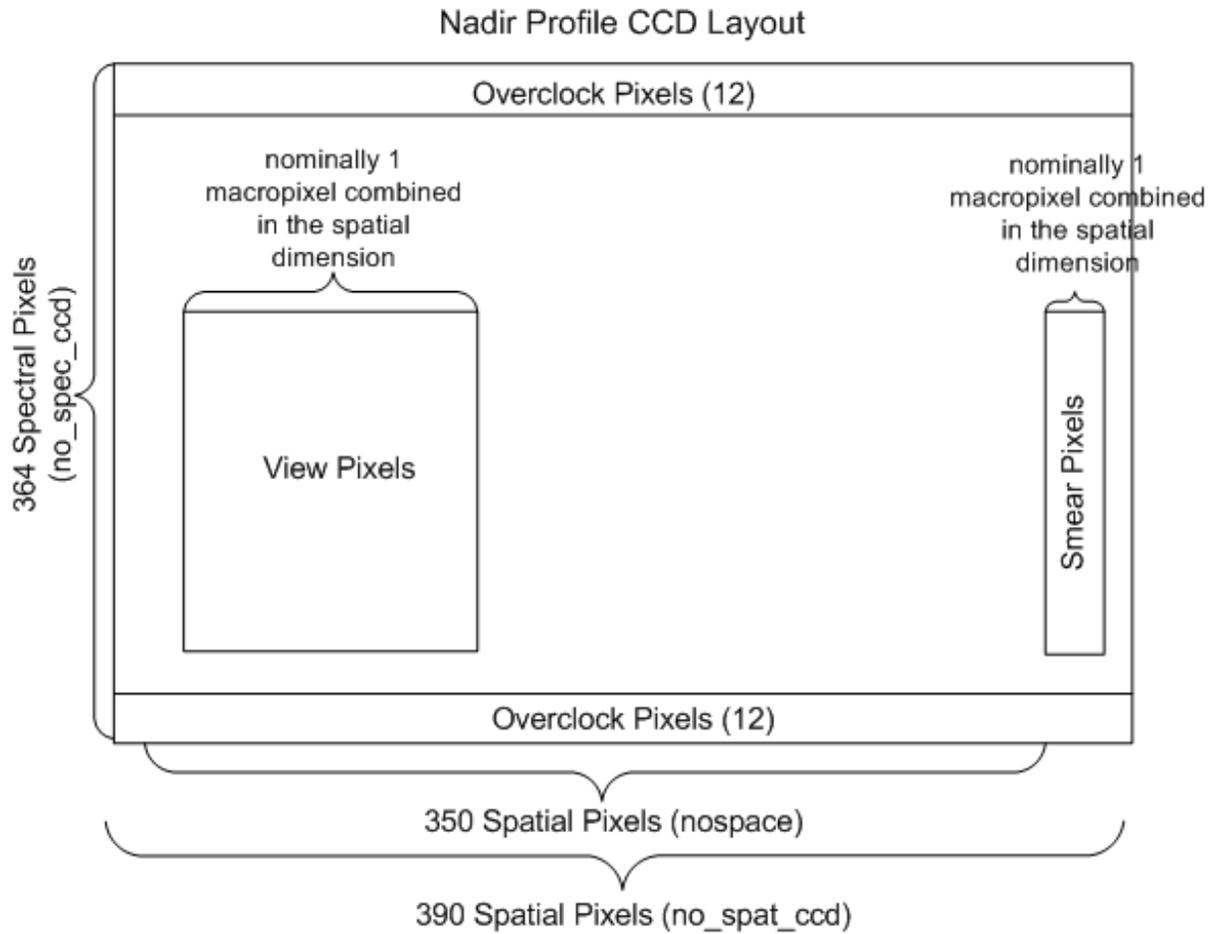
For ease of coding, the smear pixels and non-smear pixels were treated in separate arrays. All of the arrays are described using a series of vectors throughout the code. In all the most recent versions of the DADDs, only one macropixel is expected for NP, but the flexibility to allow for additional macropixels has been built into the code.

Figure A-1 and Figure A-2 visually show some of the dimensions described in the table. Whenever the array refers to a pixel size it is relative to the frame of reference shown in Figure A-1. Figure A-2 shows the maximum sizes of the smear and view regions, but the typical used region is much smaller, as indicated in Figure A-1.

Table A-1. Parameter Definitions

Parameter	Definition and Notes
maxctpx	**Maximum number of cross track macropixels. (fixed 5)**
maxsmear	**Maximum number of cross track smear macropixels. (fixed 1)**
maxmac	**Total number of macropixels (smear and view) (fixed 6, maxctpx + maxsmear)**
noctpx	**Variable Number of view macropixels (nominally 1)**
nosmear	**Number of smear macropixels (nominally 1)**
no_spat_ccd	**total number of spatial pixels on the CCD (fixed 390)**
no_spec_ccd	**total number of spectral pixels on the CCD (fixed 364)**
nospace	**total number of spatial pixels on the CCD without smear (tunable 350)**
max_macros	**Maximum number of macropixels. (fixed 2184, maxmac*no_spec_ccd)**

macrospat(max_m acros,4)	**(nmacro,1) : start spatial pixel of this macropixel** **(nmacro,2) : end spatial pixel of this macropixel** **(nmacro,3) : size on CCD** **(nmacro,4) : cross track macro pixel number (FOV) of this macropixel (1 to noctpx)**
macrotype(max_m acros)	**Type of macropixel for each macropixel: 1 = view macropixel, 2 = smear macropixel**
macromin(maxma c,2)	**macromin(1:noctpx,1) : minimum location in CCD coordinates of view pixels in the spatial dimension** **macromin(1:noctpx,2) : minimum location in CCD coordinates of view pixels in the spectral dimension** **macromin(noctpx+nosmear,1) : minimum location in CCD coordinates of smear pixels in the spatial dimension** **macromin(noctpx+nosmear,2) : minimum location in CCD coordinates of smear pixels in the spectral dimension**
macromax(maxma c,2)	**macromax(1:noctpx,1) : maximum location in CCD coordinates of view pixels in the spatial dimension** **macromax(1:noctpx,2) : maximum location in CCD coordinates of view pixels in the spectral dimension** **macromax(noctpx+nosmear,1) : maximum location in CCD coordinates of smear pixels in the spatial dimension** **macromax(noctpx+nosmear,2) : maximum location in CCD coordinates of smear pixels in the spectral dimension**
macrosize(maxma c,2)	**macrosize(1:noctpx,1)=Earth spatial view bounding box** **macrosize(1:noctpx,2)=Earth spectral bounding box** **macrosize(noctpx+nosmear,1)=Smear spatial view bounding box** **macrosize(noctpx+nosmear,2)=Smear spectral bounding box**
macrospec(max_m acros)	**spectral location of each of the macropixels**
badpixBATC	**Dimensions: (2,no_spat_ccd, no_spec_ccd)** **1st dimension = array electronics (primary or redundant)** **Values:** **< 1 = unused pixel** **1 = good pixel**
solarmaskBATC	**(no_spat_ccd,no_spec_ccd)** **Values:** **0 = not used** **1 = used**

Nadir Profile CCD Layout

Figure A-1. Layout of Nadir Profile CCD
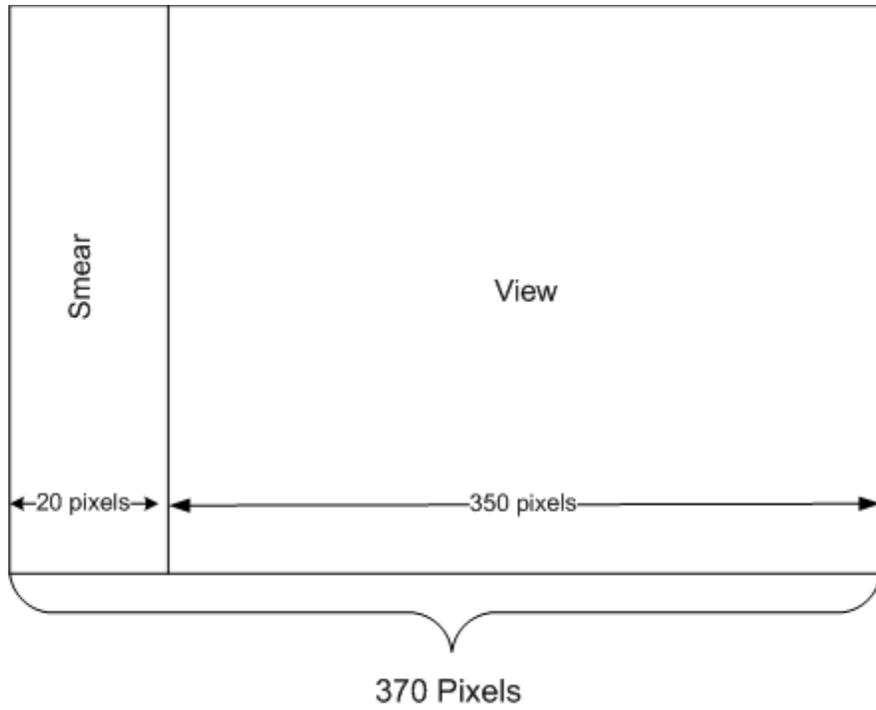
Figure A-2. Clipped Layout of NP CCD