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Goddard Space Flight Center

OMPS PEATE Concept Of Operations

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1 Overview

1.1 Introduction

The Office of Earth Science (OES) of the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration's (NOAA) National Environmental Satellite, Data, and Information Service (NESDIS) Integrated Program Office (IPO), have agreed to jointly implement a mission called the NPOESS Preparatory Project (NPP).

NPP has the objectives listed below.

1. Demonstrate and validate:
   (a) A global imaging radiometer and a suite of two sounding instruments, associated algorithms, and data processing
   (b) The Ozone Mapping and Profiling Suite (OMPS) instrument, associated algorithms, and data processing
   (c) A NPP Command, Control and Communications Segment (C3S), an Interface Data Processing Segment (IDPS), an Archive and Distribution Segment (ADS), and a Science Data Segment (SDS).
2. Provide continuity of systematic, global, calibrated, validated and geo-located Earth science imaging radiometry, sounding observations, and ozone mapping and profiling observations for NASA Earth Science research.

The SDS will include a number of Product Evaluation and Test Elements (PEATEs) that will perform various levels of analysis on NPP calibration parameters and data products as necessary to determine data quality

1.2 Document Overview

This *Concept of Operations* will describe the OMPS PEATE from an operational point of view. This will include a high-level description of the system, its interfaces and interactions with other entities, and some expected operational scenarios. It serves as the roadmap for PEATE development and testing.

1.3 Referenced Documents

Ref	Doc ID	Document	Version
1	`OMPS-SRD-0.9.1`	*OMPS PEATE System Requirements Document*	0.9.1

2 System Description

2.1 NPP Overall Context

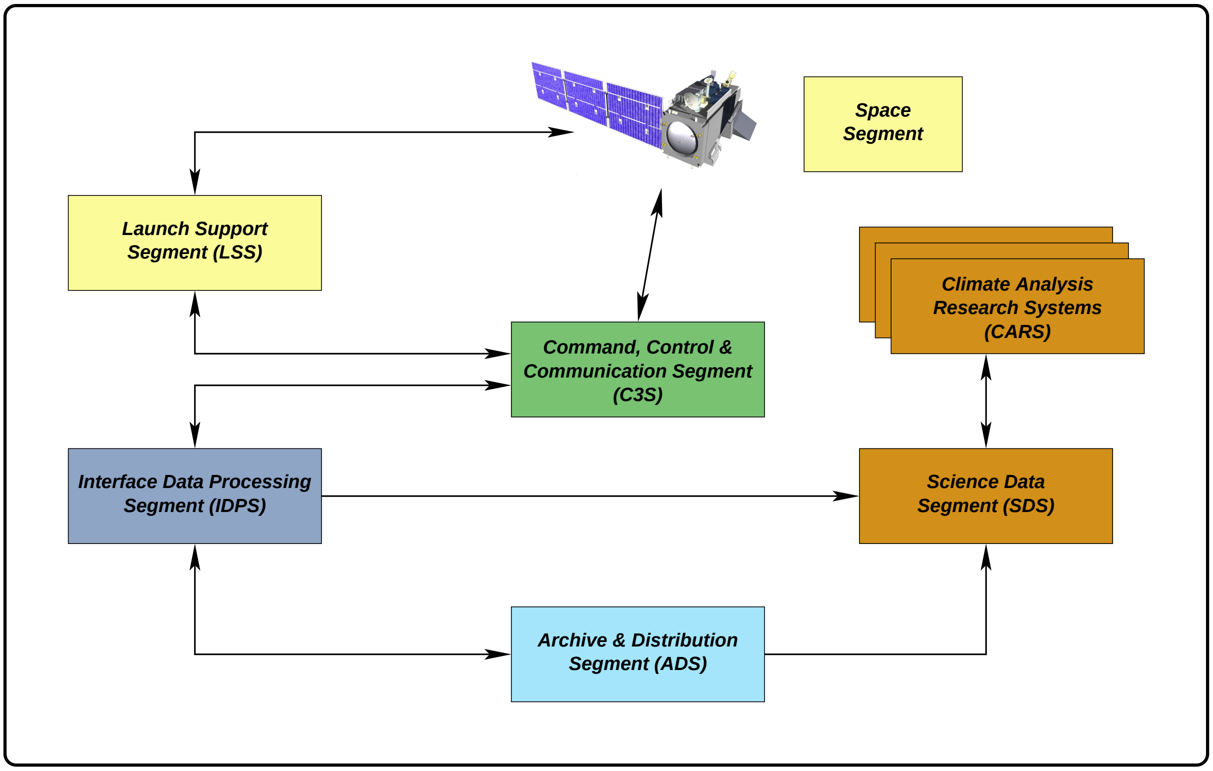

Figure 1: NPP Overall Context

The organization of the NPP mission is depicted in Figure 1. The NPP mission system is divided into a number of segments. Each of these segments has unique requirements and responsibilities to the NPP mission. The Science Data Segment (SDS) is the NASA climate research tool. This *Concept of Operations* focuses on one element within the SDS, so in order to put the SDS into a context, below is a brief description of all the NPP segments.

Space Segment (SS): The SS consists of the satellite and ground test support equipment. The satellite is comprised of the spacecraft and instruments. The instrument complement includes: Visible-Infrared Imager Radiometer Suite (VIIRS), Cross-Track Infrared Sounder (CrIS), Ozone Mapping Profiling Suite (OMPS), and the Advanced Technology Microwave Sounder (ATMS).

Launch Support Segment (LSS): The LSS provides those assets and services associated with the launch vehicle (LV) and the payload integration. Included along with the launch vehicle are all ground support equipment, property, and facilities to integrate the spacecraft to the LV, verify their integration, and conduct pre-launch testing with the remainder of the ground system.

Command, Control, and Communications Segment (C3S): The C3S provides the NPP satellite operations capabilities, communication routing of mission data and the ground receive station. The

C3S also provides for the overall mission management, coordinating the joint program operations needs. Mission Management represents both the operational and scientific communities.

Interface Data Processing Segment (IDPS): The main functions of IDPS are to ingest pre-processed Stored Mission Data, process and generate Raw Data Records (RDRs), Sensor Data Records (SDRs), and Environmental Data Records (EDRs) operationally, and provide processed data to the Centrals and ADS.

Archive and Distribution Segment (ADS): The purpose of the ADS is to receive and archive RDRs, SDRs, and EDRs from the IDPS. These data are archived, as are the associated metadata, upon which users may search and order data. Upon request, ADS processes user orders and distributes the data.

Science Data System (SDS): The SDS is a prototype element of the future NASA Earth Science Enterprise distributed science data system. The SDS is intended to be a research tool. The SDS is dependent on receiving ERDs, RDRs, and SDRs from the ADS.

Climate Analysis Research System (CARS): CARSs are independent systems that host elements of the SDS: the PEATEs. The purpose of each CARS is to focus on a particular aspect of earth sciences. The SDS, CARSs, and PEATEs are described in the next section.

2.2 Science Data Segment

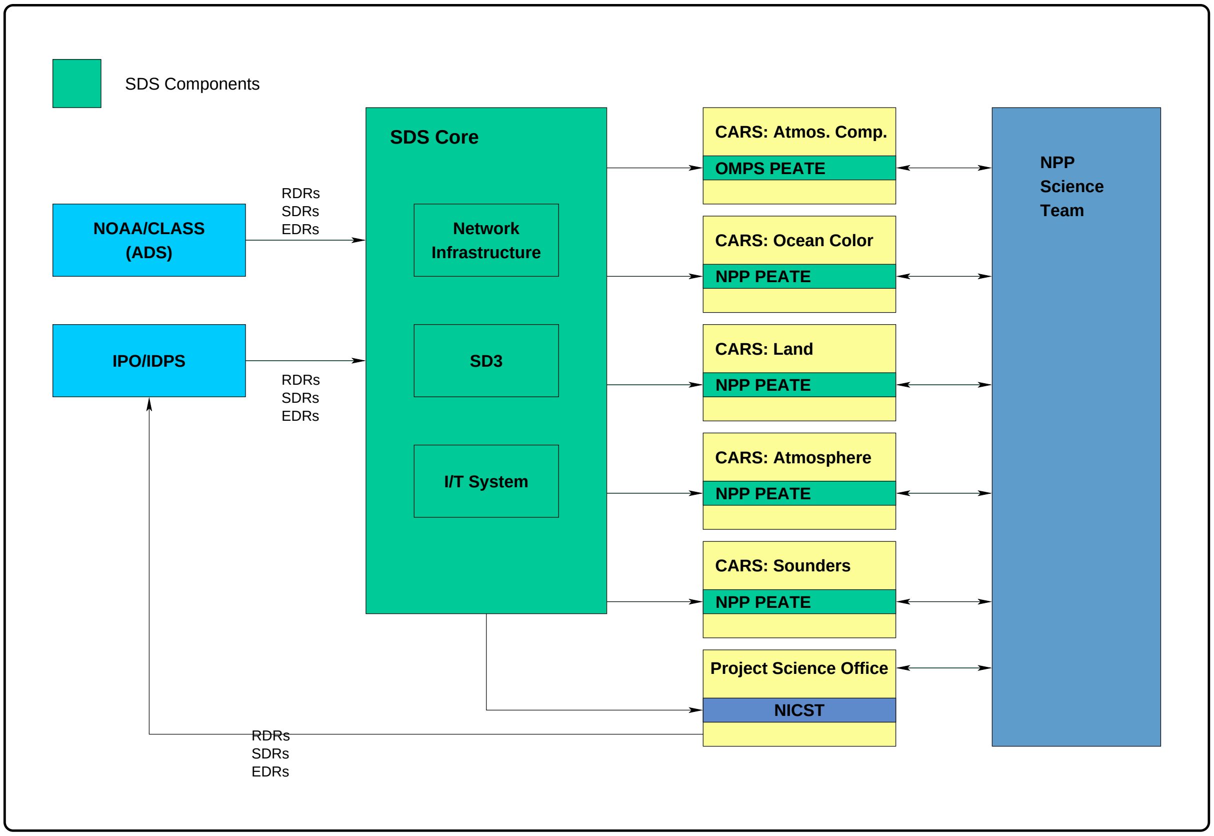

Figure 2: SDS Structure

The Science Data Segment (SDS), described in document TBS, is depicted in Figure 2. It consists of a central core of functions that are surrounded by five Climate Analysis Research Systems (CARSs). Although the CARSs are independent, they host elements of the SDS, the PEATEs.. Each CARS is dedicated to a particular aspect of Earth Sciences: Atmos. Comp., Ocean Color, Land, Atmosphere, and Sounders.

Within each CARS there are one or more Product Evaluation and Test Elements (PEATEs). For NPP ozone data, the OMPS PEATE is dedicated to performing investigations related to OMPS calibration and analysis of NPP OMPS Environmental Data Records (EDRs).

PEATEs are systems used by NASA NPP Science Teams. The OMPS PEATE, as the others, interface directly with its Science Team. More about that later.

The SDS Core provides unified interfaces in the direction of the NPP IPO. The Core acquires all NPP data products from the IDPS and from the ADS. Acquired products are buffered within the Core in the Data Delivery Depository (SD3), then provided to the CARS and to the PEATEs within. Although the PEATEs are distributed and independent, the common interface provided by the SDS Core aids in the interoperability of the whole system.

The SDS Core also provides shared functions for the CARSs. The Integration and Test (I/T) system is a resource for dealing with IDPS software. The OMPS PEATE will draw upon that resource in various ways when investigating the original IDPS OMPS software.

The SDS Core also provides a unified interface with the Project Science Office that coordinates a variety of activities within the system. One of the notable functions is to facilitate the cumulative feedback from the PEATEs back to the IPO concerning proposed SDR and EDR algorithm improvements.

2.3 OMPS PEATE Context and Interfaces

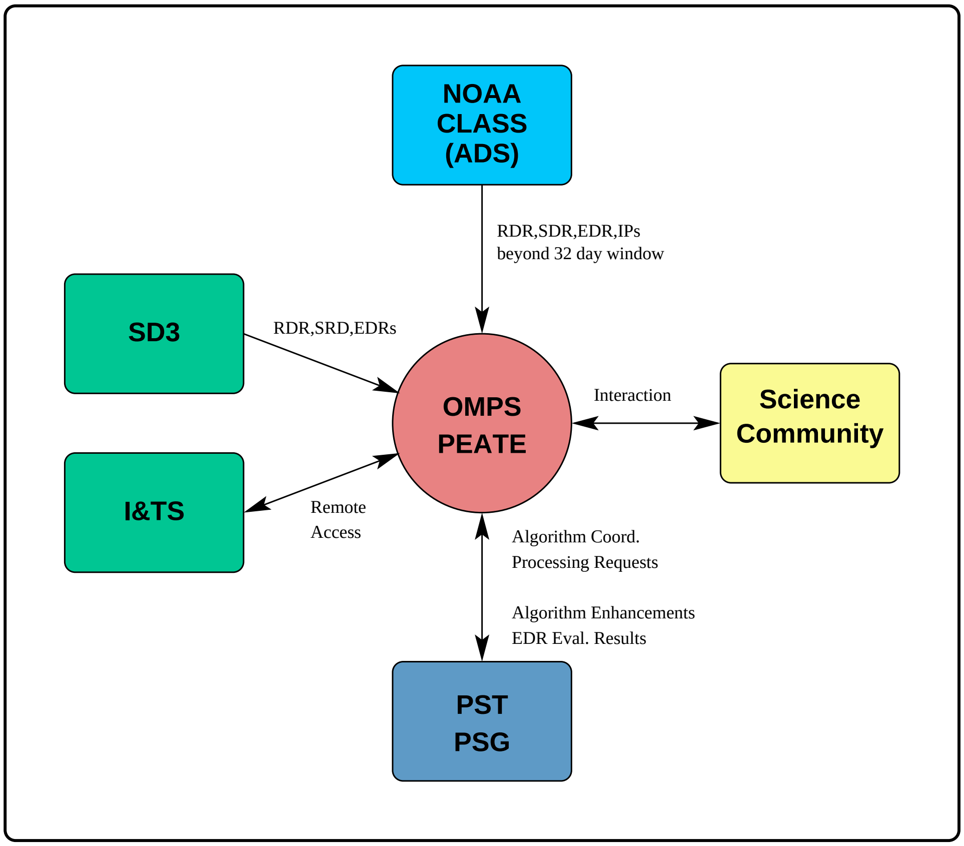

Figure 3: OMPS PEATE Context

The OMPS PEATE is a system with a number of interfaces to other elements of the project as shown in Figure 3. Within its core, the OMPS PEATE ingests, stores, processes, manages, and exports software and data in support of the OMPS PEATE Science Team's activities. All of the OMPS PEATE functions are geared toward the Science Team's need to characterize, verify, analyze, and evaluate the OMPS calibration and IDPS-generated EDRs. The OMPS PEATE internals are further described in the next section.

As shown in Figure 3, the OMPS PEATE has a number of interfaces that include the following:

SD3: The OMPS PEATE will acquire OMPS RDRs, SDRs, and Ozone EDRs from the SDS Data Delivery Depository (SD3), a component within the SDS Core. All RDRs, SDRs, and EDRs will be acquired as they are made available at the SDS interface.

I&TS: The SDS Integration and Test System (I&TS) will provide shared resources to the OMPS PEATE that would not be cost effective to replicate within each PEATE. Included would be access to a test environment in which original IDPS software could be examined and analyzed. This interface is a secure remote interactive login access from the PEATE into the SDS I&TS subsystem.

ADS: Although most files from the IPO will be received by the OMPS PEATE through the SD3 interface, the OMPS PEATE will have the capability to retrieve files on demand directly from the

NOAA/CLASS Archive and Distribution System (ADS) on an ad-hoc basis. This may be necessary to replace lost files or to acquire other data stored in the ADS.

PST: The OMPS PEATE will be the primary facility for analyses and evaluations performed by the NASA NPP OMPS Project Science Team (PST). The PEATE will provide access to data and tools for ad-hoc analysis of EDRs and algorithms. The PST will coordinate processing requests and provide suggested algorithm enhancement requests to the PEATE for development and implementation.

Science Community: The OMPS PEATE will provide a repository for information about the OMPS data and algorithms and their assessments. The repository will be available for browsing by the greater Ozone Science Community. It will support interactive feedback from the Community and provide access to data sets and metadata databases as allowed by data release policies.

2.4 OMPS PEATE Organization

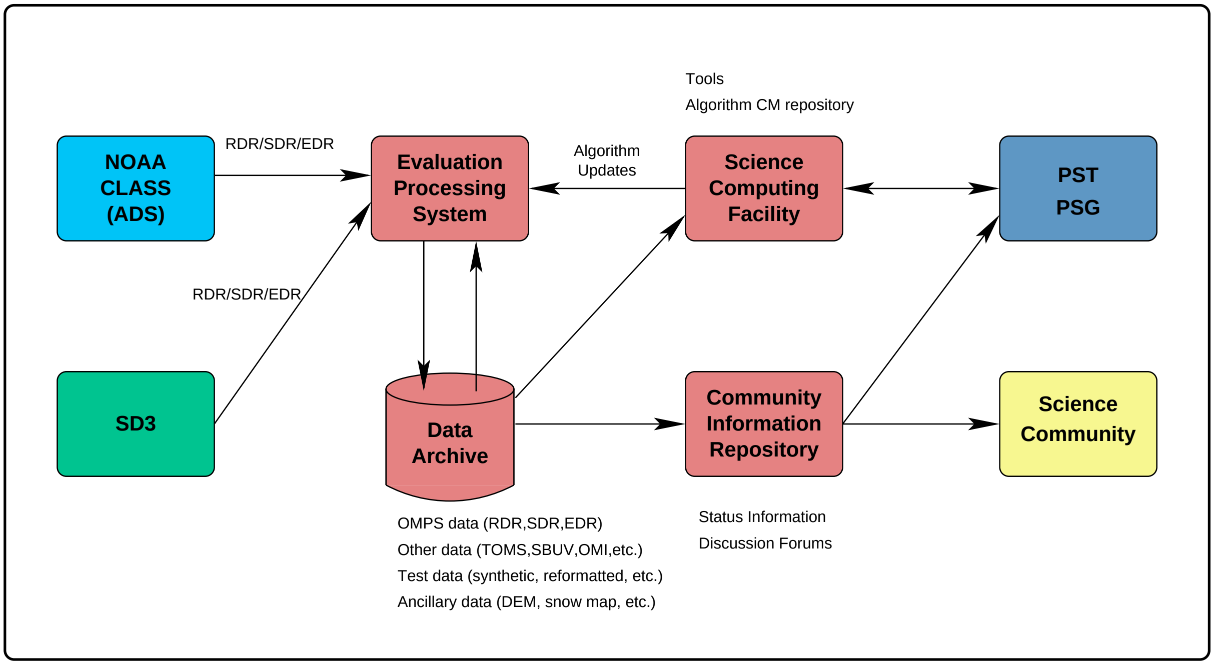

Figure 4: OMPS PEATE Organization

Figure 4 breaks down the OMPS PEATE into four major subsystems: the Evaluation Processing System, the Data Archive, the Science Computing Facility, and the Community Information Repository.

2.4.1 Evaluation Processing System

The Evaluation Processing System has the capability to ingest data from external entities, store it, and execute processing algorithms on the data to transform it. The transformations include standard processing such as the algorithms to produce SDRs and EDRs from RDRs for evaluation of the operational algorithms. It also includes Level 3 processing to produce products re-binned geographically or temporally for evaluation of the input data sets. The Evaluation Processing System can also run other analysis algorithms producing products such as residuals or derived metadata.

The Evaluation Processing System includes a database of metadata produced in conjunction with the data products. Analysis algorithms can also generate additional “derived metadata” that is also stored in the same database. The metadata can be interactively plotted for comparisons and to determine trends, or they can be downloaded to the OMPS Science Team workstations for offline analysis.

2.4.2 Data Archive

Data produced by the Evaluation Processing System is stored in a Data Archive where it is available to the Science Computing Facility for ad-hoc analysis. In addition to OMPS data (RDRs, SDRs, EDRs), the Data Archive would also hold data from other instruments (e.g., TOMS, SBUV, OMI), test data (synthetic data and reformatted data), and ancillary data needed for EDR evaluations (for example DEMs or snow maps).

2.4.3 Science Computing Facility

The Science Computing Facility will support direct interaction from the Science Team Members and host evaluation tools such as IDL, ENVI, HDFView, HDFLook, FLINT, hdiff, heex, and hemu – just to name a few. It will also include compilers, libraries, and debuggers for building, integrating, and testing algorithm software.

The Science Computing Facility will also have a Configuration Managed repository. The repository will be employed primarily for algorithms and software used in the Evaluation Processing System. It will also serve as a library of software acquired for evaluation by the OMPS Science Team.

2.4.4 Community Information Repository

The Community Information Repository is mostly a web site that includes interactive areas for tracking status of OMPS data and algorithms. Subject to data release policies, portions of the Data Archive may be accessible to the general Ozone Community through the web site. This includes access to the metadata database and to tools that produce interactive plots of primary and derived metadata. The web site would also permit members of the general Ozone Community to submit feedback to the OMPS Science Team via a moderated community forum.

3 OMPS PEATE Operational Scenarios

This section describes some potential operational scenarios for the OMPS PEATE. It is not intended to be comprehensive, limiting the scenarios, rather it depicts the type of support that is available. These scenarios are similar to "use cases" that can be employed to derive requirements for the organization and system.

3.1 Scenario 1 – Calibration Stability

A scientist wants to examine the stability of the calibration for a range of wavelengths used for producing ozone. He acquires SDRs over a period of time and runs special purpose analysis software to create plots of the data. He notices a possible artifact and wants to know if it correlates with anything about the instrument operation. The SDRs have an incomplete record of all of the housekeeping data such as temperatures and voltages and the scientist acquires the RDRs to examine the housekeeping fields not present in the SDRs.

Things this scenario requires include:

1. access to SDRs
2. access to RDRs
3. a storage system to file, catalog and retrieve the RDR and SDR data and the resulting products
4. software tools to read the RDRs and SDRs (or subsets)
5. software tools to plot and display the RDR and SDR data
6. special purpose analysis software to support the analysis that is being done
7. a mechanism to automatically run the analysis software that stages the required inputs and produces outputs

3.2 Scenario 2 – Problem-Tracking Bulletin Board

A scientist using the OMPS ozone EDR notices an interesting phenomenon in the data. It could be a great scientific discovery, but it could also be an artifact in the SDR-to-EDR algorithm process, or a problem in the instrument operation and calibration. After some initial consideration of the situation the Scientist checks the OMPS product bulletin board. There are several issues discussed on the board, but none of them seem to be related to the topic he is concerned with. So the discoverer submits a new query and describes the potential problem he is interested in. The bulletin board moderator checks the problem for compliance with NASA standards and then posts the question. The post includes a problem description and identification of the input data sets where it can be seen. The question is drawn to the attention of the NPP Science Team and any other interested scientists. Other scientists are free to comment on the question. If a member of the NPP Science Team decides or is assigned to work on the problem a note to that effect is posted. As various people think about the issue their comments are added. A calibration scientist looks at the overall issues list and decides to examine the problem in depth. More comments are added. In time the problem is associated with a possible calibration artifact and a potential solution is discovered. A sample set of data with the solution incorporated is produced and announced on the bulleting board. Interested scientists examine the "improved" data sample. After some iteration a consensus as to how the problem could be resolved is reached. If the consensus is that the priority of the problem is sufficiently high and the solution is satisfactory (both solves the problem of concern and does not introduce new problems of worse magnitude), then a more complete data set, produced with the developed corrections, is posted. This is again reviewed and, if warranted, a proposed improvement is documented and submitted to the IDPS following procedures they establish.

Things this scenario requires include:

1. a web site that provides a place for moderated submission of queries along with comments, graphical display of the problem, status of solutions, people contact information, and plans for response
2. a moderator who checks submissions for compliance with NASA requirements (e.g., profanity, abusive language, clarity, being on topic, and so on), supports the submission and staging of queries, and monitors follow on action and status reports
3. a data base that connects queries, responses, status reports, and that has links to data and images of use in the discussion
4. an interface that permits management of the database (changing of status, notifying of people, and so on)
5. sufficient storage and processing capacity to investigate selected problems and create sample corrected test data sets

3.3 Scenario 3 – Static Analysis of Algorithm

A scientist reviewing the OMPS EDR for suitability as a CDR wants to review the production algorithm for inclusion of climatically important features. He needs the source code of the production processing system. He needs to know any changes in the source code over time, along with an explanation of why the change was made and what it was intended to do. He needs to know the same information about all input files. He needs access to algorithm documentation including the Algorithm Theoretical Basis Document, ATBD, or its equivalent, and all validation and QA documents for the product.

Things this scenario requires include:

1. a web accessible document library that has all of the information or links to web accessible sites that do
2. a data base or catalog for the documents
3. a program to insure that the documents are collected and entered into the above system
4. some form of configuration management to maintain processing code status and history

3.4 Scenario 4 – Dynamic Analysis of Pre-launch Algorithm

A scientist is seeking to do pre-launch analysis of algorithms used to produce SDRs and EDRs to evaluate their suitability for making CDRs. He wants to use synthetic data in order to compare the output of the OMPS algorithms for situations where the expected output is known. This requires creation of synthetic input data sets for pre-specified situations. A given state of the atmosphere is predefined, perhaps as the output from a predecessor instrument or a numerical simulation model. This input is run through a forward model and a set of input radiances is determined. These radiances are convolved with a model of the instrument characteristics and a set of perfectly calibrated instrument output radiances is generated. This data set is then written out in the OMPS SDR format. This synthetic OMPS SDR is then run through the real OMPS SDR-to-EDR process. The resulting EDR is then compared with the pre-specified state of the atmosphere and differences are noted.

Things this scenario requires include:

1. access to the SDR-to-EDR source code pre-launch
2. implementation of this source code on a processing facility available to support this sort of investigation
3. access to the current knowledge of the instrument characteristics pre-launch
4. access to data from some prior instrument or numerical model sufficient to predefine the state of the atmosphere to be used in the comparison
5. Software and processing resources to create the desired synthetic SDR input using a forward model, the known instrument characteristics, and the format structure of the OMPS SDR
6. analysis tools to evaluate the output

3.5 Scenario 5 – Pre-launch Comparison to Another Instrument

A scientist is seeking to do pre-launch analysis of the algorithms used to produce SDRs and EDRs to evaluate their suitability for making CDRs. He wants to process data from an existing instrument through the SDR-to-EDR algorithms. In this case the input radiance values are assumed to be known as they are the already-measured values from the comparison instrument. These values are then recast to account for the difference in instrument characteristics (typically the sampling resolution and slit function) and output in a reasonable facsimile of the OMPS SDR. The production OMPS algorithm is modified as necessary to permit ingest and processing with this input. Results from this processing are compared with results from processing the original data through its own production algorithm.

Things this scenario requires include:

1. access to data, at both the SDR and EDR equivalent levels, from suitable existing instruments such as SBUV, TOMS, OMI, SCIAMACHY, and GOME
2. tools to recast SDR-like data into reasonable approximations of the OMPS SDR output
3. modified versions of the OMPS production software that will run with the recast input
4. analysis and plotting tools to support the comparison

3.6 Scenario 6 – Compensating for Long Term Trends

A scientist analyzing algorithm changes to compensate for long term trends in the instrument characteristics will need to develop proposed improvements in the RDR-to-EDR process, produce revised data with the proposed corrections, evaluate the resulting trends to assess remaining artifacts, and repeat this process as further instrument changes with time are discovered. It will also be necessary to separate changes related to instrument characteristics that should be made in the RDR-to-SDR production process from changes associated with algorithm or other input characteristics that should be made in the SDR-to-EDR process. This will require frequent and extensive processing and analysis, repeated with every change in algorithm or instrument. These studies will also need to be repeated as the available data record gets longer. Changes that could be part of the overall measurement noise in a short term record may become matters of concern as the record lengthens. Studies will often first be done with a small data set covering for instance a day out of every month, and then expanded to a day a week and then to all of the available data. This task shares many requirements for processing, storage, evaluative or comparative data, and higher level data tools.

Things this scenario requires include:

1. access to RDRs for the entire mission to-date
2. RDR-to-EDR software that lends itself to be modified
3. a processing system that can run massive processing
4. analysis tools
5. large data storage
6. a software development system with configuration control

3.7 Scenario 7 – Post-launch Comparisons to Other Instruments

A scientist is analyzing actual post-launch OMPS EDRs to assess their accuracy and suitability for climate data study. He may do studies of subsets of the OMPS data in regions and times picked to investigate specific features. He may want to compare OMPS data with other sources of information about the atmospheric ozone such as data from ground based observations (e.g., Dobson stations, umkehr stations, balloon sonde stations, lidar observation locations, and so on). He may want to compare OMPS EDRs with equivalent Level 2 data generated from other instruments flying at the same time as OMPS.

Things this scenario requires include:

1. access to the various forms of comparison data that are to be used
2. access to the OMPS EDRs and SDRs that are being evaluated
3. a system for examining the metadata associated with the OMPS data to enable intelligent selection of particular data files to be evaluated
4. ability to subset the OMPS data to the regions and times required or to generate an overpass data set for comparison with the ground based observations
5. analysis tools to support comparison with other spacecraft-based data sets

3.8 Scenario 8 – Algorithm Improvement

Once the previously-presented scenarios are executed, it is not sufficient to only point out that there are differences between OMPS products and what is desired. Rather, the NPP Team is supposed to identify changes to the production processing scheme that would produce data suitable for climate research. This requires identifying the problems of concern (done in previous steps), developing a proposed improved processing algorithm, implementing the improvement into processing code, processing a sufficient amount of data to support evaluation, and evaluating the results of the corrections. This is an iterative process until the proposed correction is shown to resolve the target problem without introducing other artifacts of note.

Things this scenario requires include:

1. analysis tools to identify problems with the SDRs and EDRs
2. programing support to implement proposed solutions
3. processing support to produce test data sets. Experience indicates that this step must be repeated numerous times over ever-increasing samples of the input data. By the time a final recommendation for an improved operational algorithm is available, this typically requires up to ten times as much processing as will be needed to support the actual production of a complete data set.
4. all RDRs available to-date
5. comparison tools
6. large data storage
7. a software development system
8. feedback from the community

3.9 Scenario 9 – Community Interchanges

Many user scientists have no real interest in detecting or resolving problems with the OMPS algorithms or the instrument. They just want to know what data is available, what time periods it covers, and what problems the data has. They will gladly share opinions about which problems need to be fixed and what the priority for fixing them should be.

Things this scenario requires include:

1. user scientist ("world") access to information about what data is available and what the plans are for making more data available
2. a simple way to globally share information about what problems are known to exit, along with illustrations of the impact
3. a way to share what are the plans for changing the data to fix the problems
4. access to reports on validation and publications about the data
5. access to the data itself
6. a mechanism for user scientists (the community) to offer opinions and suggestions

A Glossary

ADS Archive and Distribution Segment

ATBD Algorithm Theoretical Basis Document

ATMS Advanced Technology Microwave Sounder

C3S Command, Control, and Communications Segment

CARS Climate Analysis Research System

CDR Climate Data Record

CIR Community Information Repository

CrIS Cross-Track Infrared Sounder (CrIS)

CLASS ???

CM Configuration Management

CONOP Concept of Operations

DEM Digital Elevation Model

EDR Environmental Data Record

ENVI software from RSI for visualization, analysis, and presentation of digital imagery

ESA European Space Agency

FLINT Fortran LINT

GOME Global Ozone Monitoring Experiment

HDF Hierarchical Data Format

IDL Interactive Data Language (software from RSI)

IDPS Interface Data Processing Segment

IPO Integrated Program Office

LINT static source code analyzer for C

LSS Launch Support Segment

LV Launch Vehicle

NASA National Aeronautics and Space Administration

NCST NASA NPP Characterization Support Team

NESDIS National Environmental Satellite, Data, and Information Service

NOAA National Oceanic and Atmospheric Administration

NPOESS National Polar-orbiting Operational Environmental Satellite System

NPP NPOESS Preparatory Project

OES Office of Earth Science

OMI Ozone Monitoring Instrument

OMPS Ozone Mapping and Profiler Suite

PEATE Product Evaluation and Test Element

PSG ???

PST Project Science Team

QA Quality Analysis

RDR Raw Data Record

RSI Research Systems Inc.

SBUV Solar Backscatter Ultra Violet instrument

SCIAMACHY SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY (an instrument on board the ESA Envisat satellite)

SDR Sensor Data Record

SDS Science Data Segment

TOMS Total Ozone Mapping Spectrometer

VIIRS Visible-Infrared Imager Radiometer Suite