National Aeronautics and Space Administration
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Cloud Aerosol Transport System (CATS)

Data Management System

Data Products Catalog

Release 3.0: L1B Version 2.06, L2O version 1.02

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Feb. 29, 2016

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Document Revision Record

The Document Revision Record below contains information pertaining to approved document changes. The table lists the date the change is issued, the Document Change Request (DCR) number, a short description of the revision, and the revised sections.

Table 0: Document Revision Record

Issue Date	DCR Number	Description of the Revision	Section Affected
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02/29/2016	3.0	Third L1 Release, First L2 Release	All

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Acronyms

ASL, AMSL	Above Mean Sea Level
CAPS	CATS Automated Processing System
CATS	Cloud Aerosol Transport System
CPL	Cloud Physics Lidar
DEV	Development (e.g. Product)
DMS	Data Management System
GMAO	Global Modeling and Assimilation Office
GSFC	Goddard Space Flight Center
HDF	Hierarchical Data Format
HSRL	High Spectral Resolution Lidar
ISS	International Space Station
L0	Level 0 (e.g. data)
L1	Level 1 (e.g. data)
L2	Level 2 (e.g. data)
L3	Level 3 (e.g. data)
MSFC	Marshall Space Flight Center
NRT	Near Real Time
OPS	Operational (e.g. Product), Operations (e.g. activity)
POIC	MSFC Payload Operations Integration Center
STD	Standard (e.g. Product)
3WL	Three Wavelength
PL-UAD_16	Dataset 16 of the ISS Payload Unique Ancillary Data
CTRS	Conventional Terrestrial Reference System

Symbols, SI Units

ua	astronomical unit
deg	degree
°C	degree Celsius
J	Joule
K	kelvin
km	kilometer
m	meter
mb	millibar
mrad	milli radians
μrad	micro radians
ms	millisecond
nm	nanometer
Pa	Pascal
per, %	percent
s, sec	second
sr	steradian
V	volt
W	watt
μm	micron, micrometer

Data Type Abbreviations

Char	Character, 8 bits or 1 byte
Float_32	Floating Point, 32 bits or 4 bytes
Float_64	Floating Point, 64 bits or 8 bytes
Int_8	Integer, 8 bits or 1 byte
Int_16	Integer, 16 bits or 2 bytes
Int_32	Integer, 32 bits or 4 bytes
MB	MBytes, megabytes, or bytes/1024^2
UInt_8	Unsigned Integer, 8 bits or 1 byte
UInt_16	Unsigned Integer, 16 bits or 2 bytes
UInt_32	Unsigned Integer, 32 bits or 4 bytes

1.0 Introduction

The Cloud-Aerosol Transport System (CATS), launched on 10 January 2015, is a lidar remote sensing instrument that provides range-resolved profile measurements of atmospheric aerosols and clouds. Data from CATS is used to derive properties of cloud/aerosol layers including: layer height, layer thickness, backscatter, optical depth, extinction, and depolarization-based discrimination of particle type. The instrument is located on the Japanese Experiment Module – Exposed Facility (JEM-EF) on the International Space Station (ISS). The ISS orbit is a 51-degree inclination orbit at an altitude of about 405 km. This orbit provides more comprehensive coverage of the tropics and mid-latitudes than sun-synchronous orbiting sensors, with nearly a three-day repeat cycle. CATS is intended to operate on-orbit for up to three years. The CATS payload is designed to provide a combination of long-term operational science, in-space technology demonstration, and technology risk reduction for future Earth Science missions.

The measurements of atmospheric clouds and aerosols provided by the CATS payload are used for three main science objectives, which include:

1. Extend Lidar Climate Observations
    - Provide measurements of cloud and aerosol profiles similar to CALIPSO, filling the potential data gap if CALIPSO were to cease operation before another space-based lidar mission begins.
    - Create continuity in the global lidar record by collaborating with CALIPSO to create similar data products.
    - Provide measurements at various local times to promote studies of diurnal changes in clouds and aerosols.

2. Provide Observational Data to Improve Operational Modeling Programs
    - Improve model performance through assimilation of near-real-time data products, utilizing the near-instantaneous data download capabilities of the ISS
    - Improve Air Quality forecasts and hazard warning by providing the vertical distribution of aerosols in near-real-time.
    - Advance aerosol typing accuracy from space-based lidar using the new capabilities of the CATS instrument (spectral depolarization, 355 nm, etc.)

3. Advance technology in support of future space-based lidar mission development
    - Demonstrate HSRL retrieval of aerosol extinction from space and provide observational data at 355 nm for Aerosols, Clouds, Ecosystems (ACE) mission development
    - Laser Technology Demonstration/Risk Reduction: high repetition rate, injection seeding (HSRL), and wavelength tripling
    - Exhibit the utility of photon-counting detection and high rep-rate lidar systems for future cloud and aerosol missions.

To meet these three science goals, CATS operates in three different modes using four instantaneous fields of view (IFOV) as shown in Figure 1.1:

- ***Mode 7.1: Multi-beam backscatter detection at 1064 and 532 nm, with depolarization measurement at both wavelengths***. The laser output is split into two transmit beams, one aimed 0.5º to the left and one 0.5º to the right, effectively making two tracks separated by 7 km (~4.3 mi) at Earth's surface. This operational mode can no longer be used due to a failure in laser 1 electronics.
- ***Mode 7.2: Demonstration of HSRL aerosol measurements***. This mode was designed to use the injection-seeded laser operating at 1064 and 532 nm to demonstrate a high spectral resolution measurement using the 532-nm wavelength. However, this mode has been limited to 1064 nm backscatter and depolarization ratio because issues with stabilizing the frequency of laser 2 prevent collection of science quality HSRL data.
  Mode 7.3: Demonstration of 355-nm profiling. This mode was designed to use the injection-seeded laser operating at 1064, 532, and 355 nm to demonstrate 355-nm laser performance. Unfortunately, due to an unexpected failure in the laser optical path, CATS will not collect data in this mode.

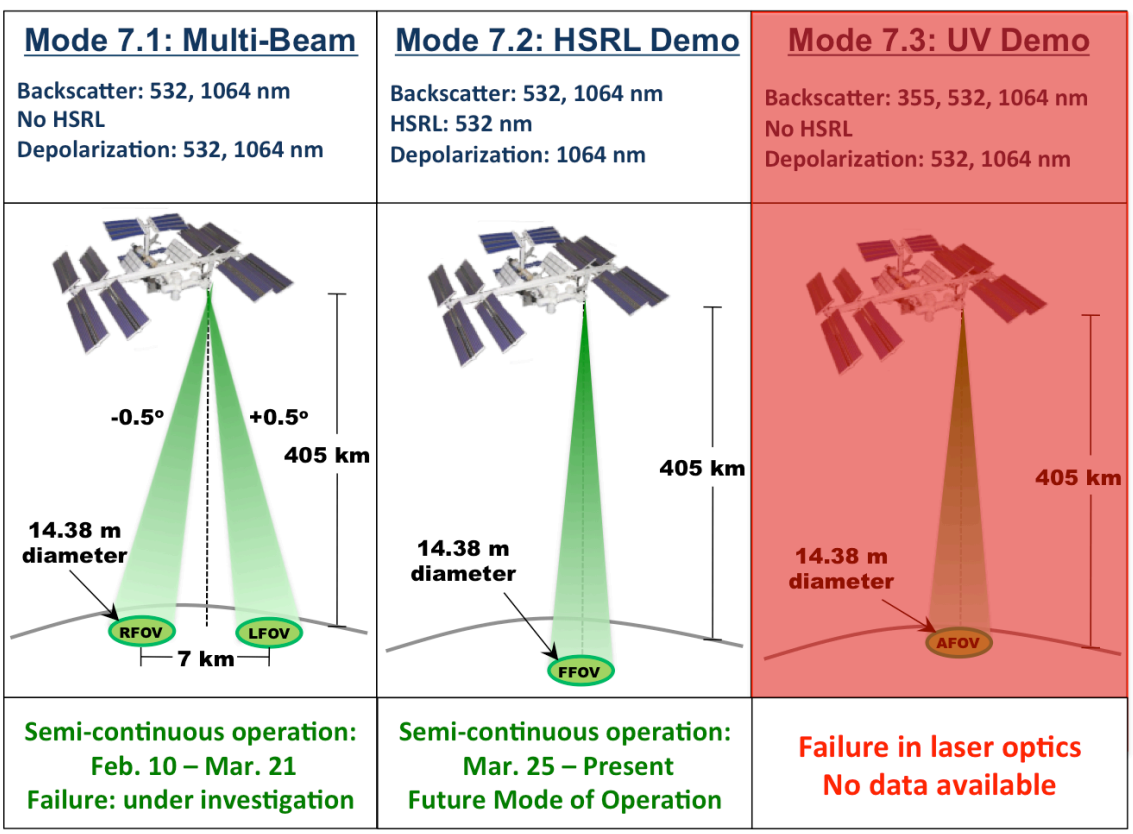

Figure 1.1 CATS three main Science Modes for operation, with details of each mode's capabilities and operational status.

The Cloud-Aerosol Transport System (CATS) payload is based on existing instrumentation built and operated on the high-altitude NASA ER-2 aircraft, including the Cloud Physics Lidar (CPL, McGill *et al.* 2002) and the Airborne Cloud-Aerosol Transport System (ACATS, Yorks *et al.* 2014). The instrument consists of two high repetition rate (4-5 kHz), low energy (1-2 mJ)

Nd:YVO4 lasers operating at three wavelengths (1064, 532, and 355 nm), a receiver subsystem with a 60 cm beryllium telescope that has a 110 microradian field of view, photon-counting detectors, and a data system to provide timing of the return photon events. More details on the CATS instrument design can be found in the CATS Algorithm Theoretical Basis Document.

The CATS Data Products Catalog (DPC) describes the CATS Automated Processing System (CAPS) and data management structure used to convert the CATS raw data into scientific data products. The DPC is intended to provide an overview of the data products that are used or produced by the Data Management System. The GSFC ICAPS processes, archives, and disseminates the CATS data products in Hierarchical Data Format (HDF) to the scientific community.

The data products generated from the CATS measurements are produced according to a protocol that is similar to that established by NASA's Earth Observing System (EOS), but are not required to meet any specific protocol. The CATS data product levels are defined as follows:

- **Level 0**: reconstructed, unprocessed instrument data at raw resolutions (i.e., the downlinked raw photon counts from the CATS instrument). Any and all communications artifacts (e.g. synchronization of packets, communications headers, duplicate or missing data) are removed in the L0 process.
- **Level 1A**: Level 0 data that is time-referenced, geo-located, corrected for detector nonlinearity and instrument artifacts, normalized to laser energy, and annotated with ancillary information. The CATS Level 1A data (relative normalized backscatter) is an internal product only and is not distributed.
- **Level 1B**: Level 1A data that have been calibrated, annotated with ancillary meteorological data, and processed to sensor units. The CATS Level 1B data (attenuated total backscatter and depolarization ratio) is archived as Level 1 data.
- **Level 2**: Geophysical parameters derived from Level 1 data, such as the vertical feature mask, profiles of cloud and aerosol properties (i.e. extinction, particle backscatter), and layer-integrated parameters (i.e. lidar ratio, optical depth). There will be two CATS Level 2 products:
    - **CATS Heritage L2**: L1B files that are run through the CALIPSO L2 algorithms to provide continuity in the algorithms used for the lidar climate record.
    - **CATS Operational L2**: L1B files that are run through the new operational CATS L2 algorithms, which will include new capabilities that correspond to new instrument technology.

Figure 1.2 demonstrates the CATS command/control and data communications structure. Functionally, there are five elements that make up the command/control and data communications structure: 1) CATS, 2) ISS, 3) the Marshall Space Flight Center (MSFC) Payload Integration Center (POIC), and the 4) CAPS Trek and 5) CAPS Science workstations. The POIC serves as the command and communications link between CAPS and CATS on the ISS. CATS receives instrument commands initiated from CAPS Trek to the POIC via a VPN ethernet connection. The commands are then transmitted from the POIC to the ISS over TDRS, and from the ISS to CATS using the 1553 communications circuit. In addition, CATS receives housekeeping and telemetry data from ISS via 1553. Housekeeping data includes time and

position information from dataset 16 of the ISS Payload Unique Ancillary Data. The CATS raw science data (and alignment data) are transmitted from CATS to the ISS using the JEM-EF High Rate Data Link (HRDL). The science data are then transmitted to the POIC over TDRS, and then to CAPS Trek via VPN ethernet, and finally passed through via LAN to the CAPS Science workstation for archival and Level 0, 1, and 2 processing. CATS command and data communications utilize the Consultative Committee for Space Data Systems (CCSDS) format. The command and science data represent the core of the CCSDS information packets transmitted to/from CATS, with various header information added at both POIC and ISS stages. Thus, the term raw data refers to the CCSDS packets containing core science data and headers applied between CATS, ISS, and the POIC. The final CCSDS raw data transmitted to CAPS Trek from the POIC, and passed unaltered to CAPS Science workstation for archival are referred to as Level 0 data. It is not expected that raw science data transmitted from CATS is the same format as Level 0 data archived by CAPS.

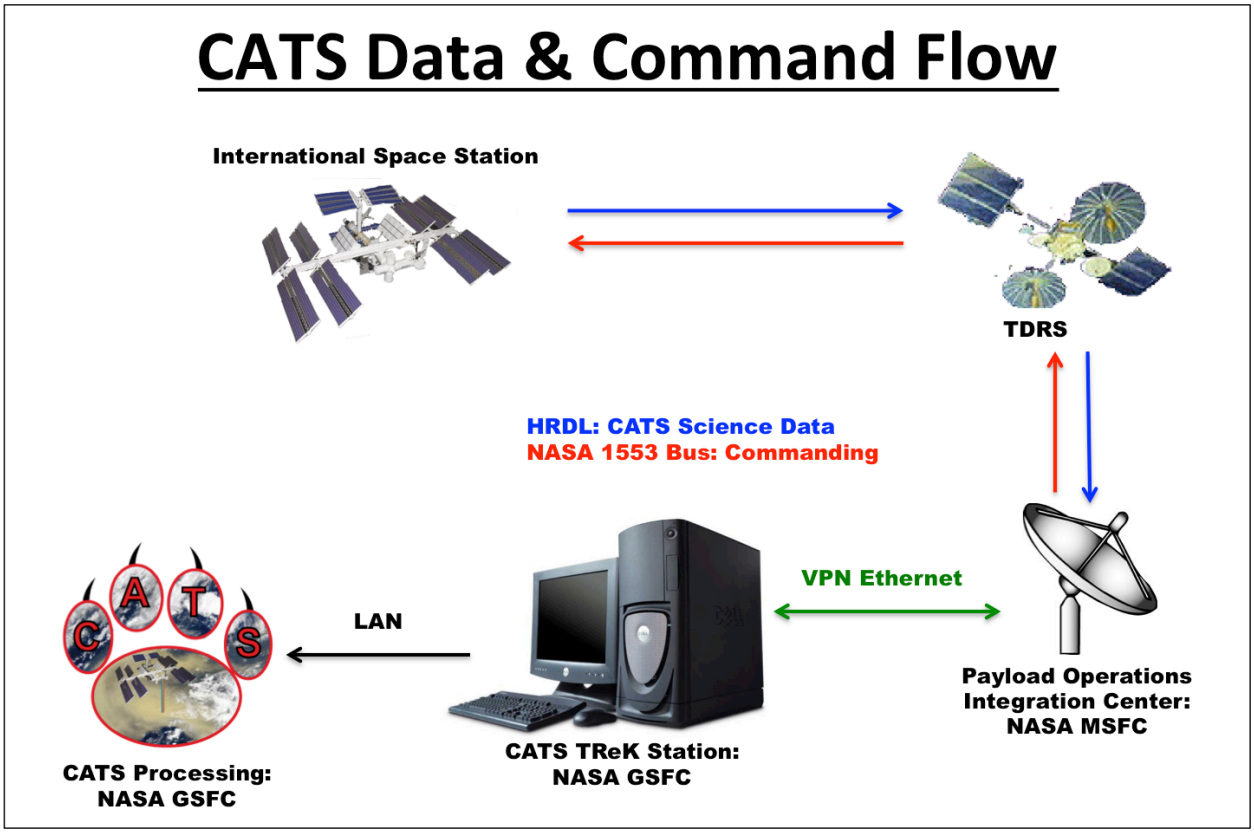

Figure 1.2. CATS Command/Control and Data Communications Structure.

1.1 CATS Definitions

Raw Data

Refers to the data collected onboard the ISS by CATS, as well as ancillary time and position data collected by CATS during operations such as the ISS Broadcast Ancillary Data (BAD). Ancillary data are added to the science data collected by CATS. The term raw data will be used to refer to any CCSDS data file or packet within CATS, CATS to the ISS, and ISS to POIC. During this

transfer process it is expected that various CCSDS headers and file/packet formatting will occur to the core science data being transmitted, and these will all be referred to as "raw data" within this document.

BAD
Refers to the ISS Broadcast Ancillary Data (BAD). It contains time and position information required for science and alignment processing. Thus any reference to BAD refers to time and/or position information.

Level 0, L0 Data
Refers to the data files/packets sent from the POIC to the CAPS Trek workstation. It is expected that all final ISS/POIC related CCSDS formatting will be completed by this stage. Level 0 files/packets will be passed, unaltered, from CAPS Trek to the CAPS Science workstation for archival and Level 1 processing.

Header
Refers to metadata and/or diagnostic information contained in both raw data files and Level 0, 1, and 2 data files.

Data Mode or Mode
Refers to the operational CATS mode during collection of scientific raw data and other activities. The mode is a programmable setting via the CAPS Trek workstation, and will be included in the raw data header. Only one mode will be active at any given time. Science and Alignment modes utilize high rate data link (HRDL) on JEM-EF. Other modes transmit data via 1553 interface on JEM-EF.

> **Mode = 1 (Off)**
> CATS is off. No power to instrument or heaters, cover door closed.
>
> **Mode = 2 (Survival)**
> Survival heaters powered, cover door closed, and instrument off.
>
> **Mode = 3 (Safe)**
> Instrument primary power applied at JEM-EF interface. Only DSEM and operational heaters are functional. Instrument housekeeping telemetry is collected and transmitted via 1553 interface. Fluid cooling loop is not active. Cover door closed.
>
> **Mode = 4 (Standby 1)**
> Fluid cooling loop is active. Laser 1 OR Laser 2 primary power converter is enabled to allow monitoring of laser housekeeping telemetry. Detectors powered. Cover door closed.
>
> **Mode = 5 (Standby 2)**
> Fluid cooling loop is active. Cover door open. Laser 1 OR Laser 2 diode driver supply enabled.

Mode = 6 (Laser Alignment)
Boresight calibration for the various science modes.

Mode = 7 (Science Mode)
The three primary science modes of the CATS instrument are described in section 1.0 and Figure 1.1.

Field Of View (FOV), Instantaneous Field Of View (IFOV)
The FOV is defined as the angular area of the atmosphere and surface scene viewed by CATS in a given mode. CATS utilizes a telescope with a full 16 mrad FOV, but is configured with four different IFOV orientations to accommodate each mode and the mission science goals. The IFOV of each orientation described below is 115 μrad.

LFOV (Left IFOV)
This refers to the FOV oriented 8 mrad to the left off nadir of the +X direction of the ISS. It is off track, tilted 8 mrad left of nadir.

RFOV (Right IFOV)
This refers to the FOV oriented 8 mrad to the right off nadir of the +X direction of the ISS. It is off track, tilted 8 mrad right of nadir.

FFOV (Fore IFOV)
This refers to the FOV oriented 8 mrad forward of the ISS along the +X direction. It is along track, but tilted 8 mrad forward from nadir.

AFOV (Aft IFOV)
This refers to the FOV oriented 8 mrad aft of the ISS along the +X direction. It is along track, but tilted 8 mrad aft from nadir.

Range Bin
Refers to the vertical resolution of the raw data and corresponding data frame, e.g. 60 m. Range bin resolution is synonymous with "vertical resolution" of the CATS data.

Profile, Record
A collection of range bins stacked vertically beginning at the height defined by Top Bin Altitude (see below) and continuing for a distance defined by the Data Frame. A profile refers to one instance of data collection at time X that is stored in the raw data file (and eventual Level 0 file). The phrase record refers to the header and the 12 channels of profile data corresponding to time X and current mode of operation. The record/profile temporal intervals are determined by the temporal resolution (0.05 secs), and the granule defines the number of profiles in a data file.

Number Shots Summed
Refers to the number of laser shot profiles summed to produce a single profile/record with a temporal resolution of 0.05 secs. Since the CATS lasers are high rep-rate, they actually measure a profile at 5000 Hz (laser 1) or 4000 Hz (laser 2). However due to data size constraints, these raw profiles cannot be archived aboard the ISS and transmitted to the CATS work station at

GSFC. Thus 250 of these raw profiles in mode 7.1 are summed together to produce a single profile with a temporal resolution of 0.05 secs that is reported in the CATS data products. For modes 7.2 and 7.3, 200 profiles are summed together.

Data Frame

Refers to a two-dimensional array defining the along track and vertical resolution and extent of the data contained within each data file/packet. The data frame is set from 28 km to – 2 km asl with 60 m range bins (vertical), and half an orbit with 0.05 sec along track temporal resolution (the latter would correspond to a 350 m horizontal resolution along track). The data frame is determined by the repetition frequency of the laser and the ISS altitude and the need to avoid pulse overlap within the atmospheric volume of interest (see discussion of this in section 1.0). The data frame is fixed at 30 km vertical for the CATS mission.

> **Top Bin Altitude**
>
> Refers to the altitude (ASL) at which the CATS data begins (e.g. 28 km) for a specific profile. This is derived using the onboard timing calculations required to adjust for changes in the ISS position above the earth's surface. NOTE: The bottom of the data frame is fixed at -2 km.

Granule

Level 0 files are partitioned into either day or night "granule" files based on the z-component of the solar line-of-sight unit vector reported in the ISS Broadcast Ancillary Data (BAD) and the solar background counts for the given profile. A new granule file is produced when both criteria agree for a given profile and these granules are then labeled correspondingly as either a "day" file or "night" file. It should be noted that there are occasions when the 6-hour sorting window is not large enough to fill in the data gaps caused by out-of-sequence data. In this scenario, two granules may be produced, with 4.5 minutes between the start and end times of the granules, instead of one larger granule. For more details on the process of creating a granule, please see the CATS ATBD document.

Channel

Refers to a profile of photon counts contained in the raw data with dimensions defined by the range bin and temporal resolution. Different modes will utilize a different number of channels. Thus the term channel is meaningful only when categorized: e.g. Mode 7.1, Parallel 1064nm describes one channel of data in the raw data file. Table 1.1 below shows the science modes (7.1 – 7.3) and how they are related to the various CATS detector channels. For mode 7.1, 12 channels of data are acquired across both IFOV orientations (channels 1 – 12). In mode 7.2 (HSRL mode), 12 channels of data are acquired (channels 13 – 24), 10 of which are used for the HSRL measurement. In mode 7.3, laser 2 is used in 3 wavelength mode (3WL) to acquire 8 channels of data (channels 25 – 31). Note also that some of the atmospheric measurements (for instance the 532 parallel and perpendicular for mode 7.1 and 7.3) acquire 2 channels of data. This is because the return signal is split and sent to two separate SPCM detectors as a way to increase the dynamic range. While multiple channels may be acquired for a given atmospheric measurement, it is actually the same measurement: those channels will be summed during the CAPS data processing (for modes 7.1 and 7.3).

Table 1.1. The Science Modes and corresponding detector channel numbers for the listed CATS atmospheric measurement. Note total number of available channels is 32 and each channel represents a complete profile of data.

Mode	Description	$1064_{\parallel}$	1064_{perp}	$532_{\parallel}$	532_{perp}	355_{tot}
7.1	Laser 1 RFOV (Multi-beam)	1	2	5,6	3,4	---
7.1	Laser 1 LFOV (Multi-beam)	7	8	11,12	9,10	---
7.2	Laser 2 FFOV (HSRL)	23	24	13-22	---	---
7.3	Laser 2 AFOV (355 nm)	25	26	27,28	29,30	31

Version

Refers to the major release of Level 1, and 2 data products. Version releases will occur sporadically during the mission based on offline development efforts addressing bugs and improvements to code/algorithms, and also significant changes to ancillary data. A version release will occur when a significant number of development changes have occurred, and/or other programmatic decisions. The term version may also refer to instance of a particular program/algorithm in the CAPS code library. Thus, the format for CATS version numbers is: X.YY, where X refers to the product version release and X.YY is used to identify program/algorithm versions (YY describes the program instance and X identifies which major version release it belongs to). Example: a program identified as V1.05 would be the 5th instance of the program (program version), and it would be part of CATS major release 1. Level 1, 2 and 3 data files will only use the X value.

1.2 CATS Raw Data Description

This section describes the content and format of the raw science data. This section does not address the format of any added CCSDS headers or formatting occurring onboard the ISS or POIC. It is expected that all the information required to process CATS science data are contained within the raw science data and not other CCSDS headers (which are considered of use to the ISS project only). The raw science data include a series of records at time intervals set by the DFHR. Each record contains a header followed by 12 channels of data measured by CATS at the time/position provided in the header. The header contains additional housekeeping information required for CATS processing. Each channel of data includes photon counts for each range bin for the entire data frame. Detector channels are defined in section 1.1.

1.3 CATS Data Management Structure

The CATS Automated Processing System (CAPS) converts the CATS instrument data into scientific data products. A high level view of the CAPS structure is illustrated in the Top Level Data Flow Diagram shown in Figure 1.3. The data flow diagram depicts the relationship between the data products and the subsystems that produce them. Circles in the diagram represent algorithm processes called subsystems. Subsystems are a logical collection of algorithms, which together convert input data products into output data products. Boxes with arrows entering a

circle are input data sources for the subsystem, while boxes with arrows exiting the circles are output data products.

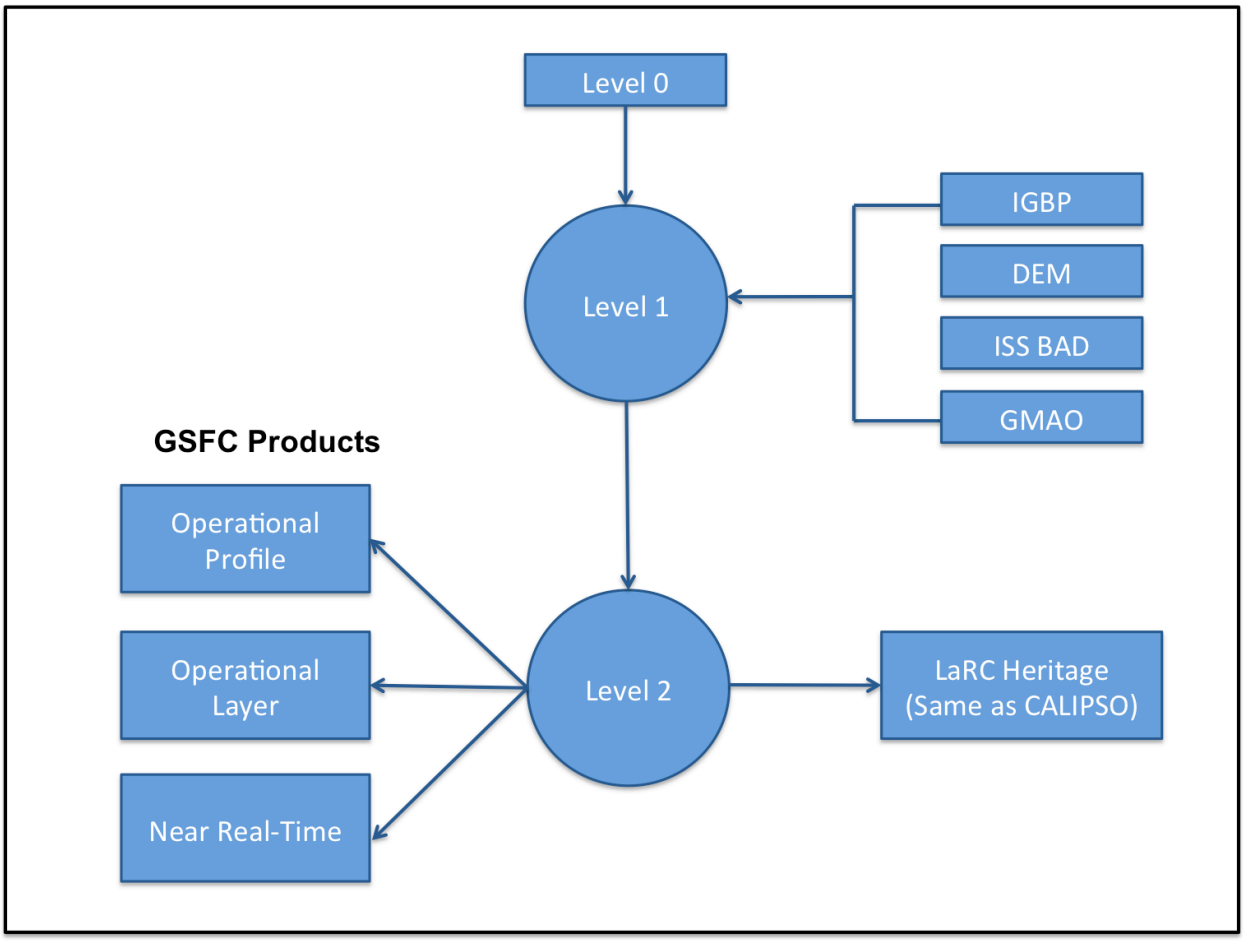

Figure 1.3 CATS Top Level Data Flow Diagram

The CATS data product naming convention is defined as:

[Investigation]_[Level]_[Day-NightID]_[Version]_[Instance].hdf

where:

Investigation	= Mission Name (CATS-ISS)
Level	= Product Level, e.g., L0, L1A, L1B, L2O,
ProductID	= Product Identification, [D or N]
Version	= VX-YY [e.g. V1-00]
Instance	= YYYY-MM-DDThh-mm-ssThh-mm-ssUTC

An example of this naming convention is:

CATS-ISS_L1B_D-M7.1-V2-04.2015-02-28T22-36-40T23-24-25UTC.hdf5

2.0 Archival Data Products

This section describes the CATS data products, which are permanently archived at the GSFC CAPS. Each data product is a single file in HDF format. Each subsection contains a brief overview of the purpose and content of the data product followed by one or more tables listing every parameter contained in the product. The following data attributes are described in the overview sections:

- Level – Data product levels are defined using EOS definitions[1]
- Type – Data type (Science Archival, Level 0, Ancillary, or Engineering)
- Frequency – How often the product is received or produced
- Time interval Covered
    - File – Time period covered within this file
- Spatial resolution
    - Record – Vertical and horizontal coverage
- File Name(s) – The name of the data product (Listed with Production Strategy, Version, and

Additional tables contain the following attributes for each parameter:

- Parameter Name – Name of parameter
- Data Type – Data type definition of the parameter value
- Units – Units of the parameter value
- Range – Range of values for the parameter (Note: For many parameters, "Range" indicates the nominal range physically meaningful values. Some small fraction of values may fall outside this range due to noise. Check the associated Uncertainty and QA parameters for guidance on data quality.)
- Elements/Record – elements per record for this parameter

Total file sizes also are provided.

2.1 Lidar Level 1A Data Product

The CATS Level 1A data is referred to as the Normalized Relative Backscatter (NRB) and is an internal product only that is not distributed. The NRB data is Level 0 data that is geolocated, corrected for detector nonlinearity and the folding of molecular signal from the atmosphere above, normalized to laser energy, and annotated with ancillary information. The ancillary information included in the NRB data is the Broadcast Ancillary Data (BAD) from the ISS that describes the environment in which a payload is operating. The BAD is sent at a rate of 10 Hz and includes the roll, pitch and yaw of the ISS, the quaternion, and the CTRS position information. Since the CATS laser points off-nadir 0.5 degrees in any of the three science modes,

and has multiple beams in Mode 7.1, the geolocation of the CATS laser beam is computed for each FOV using the BAD and the CATS relative angles. More information on the algorithm to determine the geolocation of each CATS FOV is provided in section 3.1.1. Once the data is geo-located, the raw photon counts are corrected for detector nonlinearity. The solar background photon counts is estimated by averaging the signal below the earth's surface. All the products reported in the CATS L1A data products are used as input to the CATS L1B data products. In the following table the L1A parameters are listed for all modes of operation.

Parameter	**Units**	**Type**	**Dimension**	**HDF Identifier**	**Mode**
Create_Date		String		File Creation Date	All
L1A_Creator		String		File Creator	All
Numrecs (N)		Long		Number Records	All
Operation_Mode		Float		Operation_Mode	All
Number_Channels		Uint		Number Channels	All
Number_Bins (M)		Uint		Number Bins	All
Bin_Wid_Km	km	Float		Bin Width	All
Hori_Res_Secs	s	Float		Horizontal Resolution	All
Hori_Extent	# shots	Uint		Number Shots	All
Vert_Extent	km	Float		Vertical Extent	All
Laser_Rep_Rate	Shot s^{-1}	Float		Laser Rep Rate	All
Laser_Angles	deg	Float	4	Laser Angles	All
UTC_DATE		Int4	N	UTC DATE (yyyymmdd)	All
UTC_TIME		double	N	UTC Time, fraction of day	All
Altitude_ISS	km	Float	N	ISS Altitude	All
Latitude_ISS	deg	Float	N	ISS Latitude	All
Longitude_ISS	deg	Float	N	ISS Longitude	All
Latitude_FOV	deg	Float	2,N	Footprint Latitude	All
Longitude_FOV	deg	Float	2,N	Footprint Longitude	All
Record_Number		ULong	N	Record Number	All
Day_Night_Flag		Byte	N	Day Night Flag	All
Surface_Type	IGBP	Byte	N	Surface_Type	All
Surface_Elevation	m	Int2	2,N	Surface_Elevation	All
Height_Top_Bin (km)	km	Float	2,N	Height of Top Bin (0,*) is Left FOV, (1,*) RFOV for Mode 7.1 (0,*) for other modes	All
Laser_Energies	J	Float	4,	Laser Energies	All
Laser_Energy_Variances		Float	4,	Laser Energy Variances	All
Laser_Qflag355		Byte	N	Laser Energy Quality 355	7.3
Laser_Qflag532		Byte	N	Laser Energy Quality 532	All
Laser_Qflag1064		Byte	N	Laser Energy Quality 1064	All
NRB_Perpendicular_532		Float	$2^{\#}$,M^{*},N	NRB Perpendicular 532	All[1]
NRB_Parallel_532		Float	$2^{\#}$,M^{*},N	NRB Parallel 532	All[2]
NRB_Perpendicular_1064		Float	$2^{\#}$,M^{*},N	NRB Perpendicular 1064	All
NRB_Parallel_1064		Float	$2^{\#}$,M^{*},N	NRB Parallel 1064	All
NRB_Total_355		Float	M^{*},N	NRB Total 355	7.3
Background_Perpendicular_532	Photon	Float	$2^{\#}$,N	Background Perpendicular 532	All
Background_Parallel_532	Photon	Float	$2^{\#}$,N	Background Parallel 532	All
Background_Variance_Perpendicular_532	Photon	Float	$2^{\#}$,N	Background Variance Perpendicular 532	All

Background_Variance_Parallel_532	Photon	Float	2[#],N	Background Variance Parallel 532	All
Background_Perpendicular_1064	Photon	Float	2[#],N	Background Perpendicular 1064	All
Background_Parallel_1064	Photon	Float	2[#],N	Background Parallel 1064	All
Background_Variance_Parallel_1064	Photon	Float	2[#],N	Background Variance Parallel 1064	All
Background_Variance_Perpendicular_1064	Photon	Float	2[#],N	Background Variance Perpendicular 1064	All
Background_Total_355	photon	Float	N	Background Total 355	7.3
Background_Variance_355		Float	N	Background_Variance_355	7.3
Saturated_Bins355		Int2	50,N	Saturated Bins 355 (50 max)	7.3
Saturated_Bins532		Int2	2[#],50,N	Saturated Bins 532 (50 max)	All
Saturated_Bins1064		Int2	2[#],50,N	Saturated Bins 1064 (50 max)	All
Dead_Time_Correction_Profile		Float	M,12,N	Dead Time Correction Profile	option
HSRL_Raw_Counts	photon	Int2	10,M,N	HSRL Raw Counts	7.2
HSRL_Backgrounds	photon	Float	10,N	HSRL Background Counts	7.2
Commanded_Etalon_Gap		Float	3,N	Commanded Etalon Gap	7.2
Actual_Etalon_Gap		Float	3,N	Actual Etalon Gap	7.2
Commanded_Etalon_Capacitance		Float	3,N	Commanded Etalon Capacitance	7.2
Actual_Etalon_Capacitance		Float	3,N	Actual Etalon Capacitance	7.2
CTRS_Position		Float	3,N	CTRS Position XYZ	All
CTRS_Velocity		Float	3,N	CTRS Velocity XYZ	All
CTRS_Position_Quality		UInt	N	CTRS Position Quality	All
CTRS_Position_Time		ULong	N	CTRS Position Coarse Time	All
Quaternion_Data		Float	4,N	Quaternion Data	All
Boresite_Steps_Motor		Long	7,N	Boresite Motor Step Data	All
Science_Data_Error_Flag		Byte	12,N	Science Data Error Flag	All
SPCM_Enable_Flags		ULong	N	SPCM Enable Flags	All
FOV_Angle_Fore		Float	N	CATS Fore FOV Angle	All
FOV_Angle_Aft		Float	N	CATS Aft FOV Angle	All
FOV_Angle_Right		Float	N	CATS Right FOV Angle	All
FOV_Angle_Left		Float	N	CATS Left FOV Angle	All
Yaw_ISS		Float	N	ISS Yaw Angle	All
Pitch_ISS		Float	N	ISS Pitch Angle	All
Roll_ISS		Float	N	ISS Roll Angle	All
Attenuated_Molecular_Backscatter532		Float	R[3],N	Attenuated Molecular Backscatter532	All
Attenuated_Molecular_Backscatter1064	$Km^{-1}sr^{-1}$	Float	R[3],N	Attenuated Molecular Backscatter1064	All

[*]Maxbins (M) can vary (500 for 60 m bins: default value)
[#]The 2 dimension is for Left and Right FOVs (Mode 7.1 only)
[1]In mode 7.2, the NRB_Perpendicular_532 array is all zeroes
[2]In mode 7.2 the 10 HSRL channels are summed and stored in the NRB_Parallel_532 array
[3]R is the number of MET records, appx 1/200 of N

2.2 CATS Level 1B Data Product

In the following tables, the parameters listed in black font will always be on the product regardless of operating mode. Red font denotes mode 7.1 only and blue font mode 7.2 only.

Feb 22, 2016 V2.06 Corresponds to V2-06 LIB Product Software

Table 1: CATS-ISS L1B Record Summary for Mode 7.1

Record Name	Reference Table	Record Size (Bytes)	Records /File	File Size (Bytes)
Metadata	Table 3	2,910	1	2,910
Position, Attitude and Celestial	Table 4	48	54,015	2,592,720
Geolocation and Viewing Geometry	Table 5	40	54,015	2,160,600
Elastic Backscatter	Table 6	17,317.5	54,015	935,404,762.5
Total Bytes/Granule (Mode 7.1)				**940,160,992.5**

Table 2: CATS-ISS L1B Record Summary for Mode 7.2

Record Name	Reference Table	Record Size (Bytes)	Records/ File	File Size (Bytes)
Metadata	Table 3	2,842	1	2,842
Position, Attitude and Celestial	Table 4	48	54,015	2,592,720
Geolocation and Viewing Geometry	Table 5	24	54,015	1296360
Elastic Backscatter	Table 6	6,578.5	54,015	355,337,677.5
Total Bytes/Granule (Mode 7.2)				**359,229,599.5**

Table 3: CATS-ISS Metadata Record (1 per granule)

Parameter	Data Type	Units	Elem/ Granule	Bytes
ProductID	Char	N/A	1	40
Product_Version_Number	Char	N/A	1	40
Product_Creation_Date	Char	N/A	1	40
Product_Creator	Char	N/A	1	40
Granule_Start_DateTime	Char	N/A	1	40
Granule_Stop_DateTime	Char	N/A	1	40
Granule_Production_DateTime	Char	N/A	1	40
Granule_Start_Latitude	Float	deg	1	4
Granule_Start_Longitude	Float	deg	1	4
Granule_Stop_Latitude	Float	deg	1	4
Granule_Stop_Longitude	Float	deg	1	4
Granule_Start_RDM	Float	N/A	1	4
Granule_Stop_RDM	Float	N/A	1	4
Number_Profiles	Ulong	N/A	1	4
Profile_Repetition_Rate	Int	Hz	1	2
Number_Bins	Int	N/A	1	2
Bin_Size	Float	km	1	4
Laser_Repetition_Rate	Int	Hz	1	2
Granule_Start_Record_Number	ULong	N/A	1	4
Granule_Stop_Record_Number	ULong	N/A	1	4
Ephemeris_Files_Used	Char	N/A	1	100
GEOS_Version	Char	N/A	1	100
GEOS_Files_Used	Char	N/A	1	100
*Percent_532parallel_bad	Float	%	2	8
*Percent_532perpendicular_bad	Float	%	2	8
*Percent_1064parallel_bad	Float	%	2	8
*Percent_1064perpendicular_bad	Float	%	2	8
Percent_532parallel_missing_Left_FOV	Float	%	1	4
Percent_532perpendicular_missing_Left_FOV	Float	%	1	4
Percent_1064parallel_missing_Left_FOV	Float	%	1	4
Percent_1064perpendicular_missing_Left_FOV	Float	%	1	4
Percent_532parallel_missing_Right_FOV	Float	%	1	4
Percent_532perpendicular_missing_Right_FOV	Float	%	1	4
Percent_1064parallel_missing_Right_FOV	Float	%	1	4
Percent_1064perpendicular_missing_Right_FOV	Float	%	1	4

Percent_532total_missing_Fore_FOV	Float	%	1	4
Percent_1064parallel_missing_Fore_FOV	Float	%	1	4
Percent_1064perpendicular_missing_Fore_FOV	Float	%	1	4
Bin_Altitude_Array	Float	km	533	2,132
Calibration_Top_Altitude	Float	km	1	4
Calibration_Bottom_Altitude	Float	km	1	4
Average_532ScatteringRatio_25_27km_Left_FOV	Float	N/A	1	4
Average_1064ScatteringRatio_25_27km_Left_FOV	Float	N/A	1	4
Average_532ScatteringRatio_25_27km_Right_FOV	Float	N/A	1	4
Average_1064ScatteringRatio_25_27km_Right_FOV	Float	N/A	1	4
Average_532ScatteringRatio_25_27km_Fore_FOV	Float	N/A	1	4
Average_1064ScatteringRatio_25_27km_Fore_FOV	Float	N/A	1	4
Polarization_Gain_Ratio532_Left_FOV	Float		1	4
Polarization_Gain_Ratio532_Uncertainty_Left_FOV	Float		1	4
Polarization_Gain_Ratio532_Right_FOV	Float		1	4
Polarization_Gain_Ratio532_Uncertainty_Right_FOV	Float		1	4
Polarization_Gain_Ratio1064_Left_FOV	Float		1	4
Polarization_Gain_Ratio1064_Uncertainty_Left_FOV	Float		1	4
Polarization_Gain_Ratio1064_Right_FOV	Float		1	4
Polarization_Gain_Ratio1064_Uncertainty_Right_ FOV	Float		1	4
Polarization_Gain_Ratio1064_Fore_FOV	Float		1	4
Polarization_Gain_Ratio1064_Uncertainty_Fore_FOV	Float		1	4
Average_Below_Ground_Photon_Count_532nm_Left_FOV	Float		1	4
Average_Below_Ground_Photon_Count_1064nm_Left_FOV	Float		1	4
Average_Below_Ground_Photon_Count_	Float		1	4

532nm_Right_FOV				
Average_Below_Ground_Photon_Count_1064nm_Right_FOV	Float		1	4
Average_Below_Ground_Photon_Count_532nm_Fore_FOV	Float		1	4
Average_Below_Ground_Photon_Count_1064nm_Fore_FOV	Float		1	4
Alpha_Value_532nm_Left_FOV	Y		1	4
Alpha_Value_1064nm_Left_FOV	Y		1	4
Alpha_Value_532nm_Right_FOV	Y		1	4
Alpha_Value_1064nm_Right_FOV	Y		1	4
Alpha_Value_532nm_Fore_FOV	Y		1	4
Alpha_Value_1064nm_Fore_FOV	Y		1	4
Total Bytes/Granule Mode 7.1				**2910**
Total Bytes/Granule Mode 7.2				**2842**

*These are 2 element arrays for left FOV (1) and right FOV(2)

Table 4: CATS-ISS Position, Attitude and Celestial Record

Parameter	Data Type	Units	Nominal Range	Elem/Record	Bytes
ISS_Altitude	Float	km	400 - 500	1	4
ISS_CTRS_Position_XYZ	Float	km	-8,000 – 8,000	1,3	12
ISS_CTRS_Velocity_XYZ	Float	$km \cdot s^{-1}$	5 - 10	1,3	12
ISS_Roll_Angle	Float	deg	-10 - 10	1	4
ISS_Pitch_Angle	Float	deg	-10 - 10	1	4
ISS_Yaw_Angle	Float	deg	-10 - 10	1	4
ISS_Latitude	Float	deg	-60 - 60	1	4
ISS_Longitude	Float	deg	-180 - 180	1	4
Total Bytes/Record					**48**

Table 5: CATS-ISS Profile Geolocation and Viewing Geometry Record

Parameter	Data Type	Units	Nominal Range	Elem/Record	Bytes
CATS_Left_FOV_Latitude	Float	deg	-60 - 60	1	4
CATS_Left_FOV_Longitude	Float	deg	-180 - 180	1	4
CATS_Right_FOV_Latitude	Float	deg	-60 - 60	1	4
CATS_Right_FOV_Longitude	Float	deg	-180 - 180	1	4
CATS_Fore_FOV_Latitude	Float	deg	-60 - 60	1	4
CATS_Fore_FOV_Longitude	Float	deg	-180 - 180	1	4
CATS_Left_FOV_Angle	Float	deg	-10 - 10	1	4
CATS_Right_FOV_Angle	Float	deg	-10 - 10	1	4
CATS_Fore_FOV_Angle	Float	deg	-10 - 10	1	4
Solar_Zenith_Angle	Float	deg	0 - 180	1	4
Solar_Azimuth_Angle	Float	deg	-180 - 180	1	4
Index_Top_Bin_Left_FOV	Float	km	0 - 100	1	4
Index_Top_Bin_Right_FOV	Float	km	0 - 100	1	4
Index_Top_Bin_Fore_FOV	Float	km	0 - 100	1	4
Total Bytes/Record Mode 7.1					**40**
Total Bytes/Record Mode 7.2					**24**

Table 6: CATS-ISS Elastic Backscatter Science Record

Parameter	Data Type	Units	Elem/ Record	Bytes
Profile_UTC_Date	Long		1	4
Profile_UTC_Time	double		1	8
Profile_ID	ULong		1	4
Day_Night_Flag	Byte	N/A	1	1
Surface_Type_Left_FOV	Byte		1	1
Surface_Type_Right_FOV	Byte		1	1
Surface_Type_Fore_FOV	Byte		1	1
Surface_Type_Nadir	Byte		1	1
DEM_Mean_Elevation_Left_FOV	Float	m	1	4
DEM_Mean_Elevation_Right_FOV	Float	m	1	4
DEM_Mean_Elevation_Fore_FOV	Float	m	1	4
DEM_Mean_Elevation_Nadir	Float	m	1	4
Quality_Flag532_Left_FOV	Byte		1	1
Quality_Flag532_Right_FOV	Byte		1	1
Quality_Flag1064_Left_FOV	Byte		1	1
Quality_Flag1064_Right_FOV	Byte		1	1
Quality_Flag532_Fore_FOV	Byte		1	1
Quality_Flag1064_Fore_FOV	Byte		1	1
Quality_Control_Flag	ULong	N/A	1	4
Calibration_Constant532_Left_FOV	Float		1	4
Calibration_Constant532_Uncertainty_Left_FOV	Float		1	4
Calibration_Fit_Flag_532_Left_FOV	Int		1	2
Calibration_Constant532_Right_FOV	Float		1	4
Calibration_Constant532_Uncertainty_Right_FOV	Float		1	4
Calibration_Fit_Flag532_Right_FOV	Int		1	2
Calibration_Constant532_Fore_FOV	Float		1	4
Calibration_Constant532_Uncertainty_Fore_FOV	Float		1	4
Calibration_Fit_Flag532_Fore_FOV	Int		1	2
Perpendicular_Attenuated_Backscatter532_Left_FOV	Float	$km^{-1}sr^{-1}$	533,1	2132
Perpendicular_Attenuated_Backscatter532_Right_FOV	Float	$km^{-1}sr^{-1}$	533,1	2132
Total_Attenuated_Backscatter532_Left_FOV	Float	$km^{-1}sr^{-1}$	533,1	2132
Total_Attenuated_Backscatter532_Right_FOV	Float	$km^{-1}sr^{-1}$	533,1	2132
Total_Attenuated_Backscatter532_Fore_FOV	Float	$km^{-1}sr^{-1}$	533,1	2132
Molecular_Backscatter532	Float	$km^{-1}sr^{-1}$	533,0.005	10.66
Molecular_2way_Transmission532	Float	sr^{-1}	533,0.005	10.66
Perpendicular_Background_and_Variance532_Left	Float	counts	2,1	8

_FOV				
Perpendicular_Background_and_Variance532_Right_FOV	Float	counts	2,1	8
Total_Background_and_Variance532_Left_FOV	Float	counts	2,1	8
Total_Background_and_Variance532_Right_FOV	Float	counts	2,1	8
Total_Background_and_Variance532_Fore_ FOV	Float	counts	2,1	8
Laser_532Energy_Average_Left_FOV	Float	J	1	4
Laser_532Energy_Average_Right_FOV	Float	J	1	4
Laser_532Energy_Variance	Float	J	1	4
Calibration_Constant1064_Left_FOV	Float		1	4
Calibration_Constant1064_Uncertainty_Left_FOV	Float		1	4
Calibration_Fit_Flag1064_Left_FOV	Int		1	2
Calibration_Constant1064_Right_FOV	Float		1	4
Calibration_Constant1064_Uncertainty_Right_FOV	Float		1	4
Calibration_Fit_Flag1064_Right_FOV	Int		1	2
Calibration_Constant1064_Fore_FOV	Float		1	4
Calibration_Constant1064_Uncertainty_Fore_FOV	Float		1	4
Calibration_Fit_Flag1064_Fore_FOV	Int		1	2
Perpendicular_Attenuated_Backscatter1064_Left_FOV	Float	$km^{-1}sr^{-1}$	533,1	2132
Perpendicular_Attenuated_Backscatter1064_Right_FOV	Float	$km^{-1}sr^{-1}$	533,1	2132
Total_Attenuated_Backscatter1064_Left_FOV	Float	$km^{-1}sr^{-1}$	533,1	2132
Total_Attenuated_Backscatter1064_Right_FOV	Float	$km^{-1}sr^{-1}$	533,1	2132
Perpendicular_Attenuated_Backscatter1064_Fore_FOV	Float	$km^{-1}sr^{-1}$	533,1	2132
Total_Attenuated_Backscatter1064_Fore_FOV	Float	$km^{-1}sr^{-1}$	533,1	2132
Molecular_Backscatter1064	Float	$km^{-1}sr^{-1}$	533,0.005	10.66
Molecular_2way_Transmission1064	Float	sr^{-1}	533,0.005	10.66
Perpendicular_Background_and_Variance1064_Left_FOV	Float	counts	2,1	8
Perpendicular_Background_and_Variance1064_Right_FOV	Float	counts	2,1	8
Total_Background_and_Variance1064_Left_FOV	Float	counts	2,1	8
Total_Background_and_Variance1064_Right_FOV	Float	counts	2,1	8
Perpendicular_Background_and_Variance1064_Fore_FOV	Float	counts	2,1	8
Total_Background_and_Variance1064_Fore_FOV	Float	counts	2,1	8
Laser_1064Energy_Average_Left_FOV	Float	J	1	4
Laser_1064Energy_Average_Right_FOV	Float	J	1	4

Laser_1064Energy_Variance	Float	J	1	4
Laser_532Energy_Average_Fore_FOV	Float	J	1	4
Laser_1064Energy_Average_Fore_FOV	Float	J	1	4
First_Saturated_Bin_Index532_Fore_FOV	Int		1	2
First_Saturated_Bin_Index1064_Fore_FOV	Int		1	2
First_Saturated_Bin_Index532_Left_FOV	Int		1	2
First_Saturated_Bin_Index532_Right_FOV	Int		1	2
First_Saturated_Bin_Index1064_Left_FOV	Int		1	2
First_Saturated_Bin_Index1064_Right_FOV	Int		1	2
MET_Data_Latitude	Float	Deg	0.005	.02
MET_Data_Longitude	Float	Deg	0.005	.02
MET_Data_Date	Long		0.005	.02
MET_Data_Time	Double		0.005	.04
Temperature_Profile	Float	C	533,0.005	10.66
Pressure_Profile	Float	mb	533,0.005	10.66
Relative_Humidity_Profile	Float	%	533,0.005	10.66
Surface_Wind_Velocity	Float	m/s	2,0.005	.04
Wind_Velocity_10m	Float	m/s	2,0.005	.04
Tropopause_Height	Float	km	.005	.02
Tropopause_Temperature	Float	C	.005	.02
Ozone_Mixing_Ratio	Float		533,0.005	10.66
Total Bytes/Record Mode 7.1				**17317.5**
Total Bytes/Record Mode 7.2				**6578.5**

Nominal Granule will span roughly 45 minutes (1/2 orbit) or 2700 seconds. Data rate is 20 records per second, or 20 Hz.

2.3 Lidar Level 2 Operation Layer DP

In the following tables, the parameters listed in black font will always be on the product regardless of operating mode. Red font denotes mode 7.1 only, blue font mode 7.2 only. February 12, 2016 V1-02 Corresponds to V1_02 L2 Product Software

Data File Name:
5 km Layer: CATS-ISS_L2O_D-M7.1-V1-02_05kmLay.2014-09-17T00-31-01UTC.hdf5

Table 1: CATS-ISS 5 km Layer Record Summary for Mode 7.1

Record Name	Reference Table	Record Size (Bytes)	Records/ File	File Size (Bytes)
Metadata	Table 4	2,502	1	2,502
Geolocation and Viewing Geometry	Table 5	84	4,155	349,020
Layer Descriptor	Table 6	1,262	4,155	5,243,610
Layer Optical Properties	Table 7	4,160	4,155	17,284,800
Total Bytes/Granule (Mode 7.1)		**8,008**		**22,879,932**

Table 2: CATS-ISS 5 km Layer Record Summary for Mode 7.2

Record Name	Reference Table	Record Size (Bytes)	Records/ File	File Size (Bytes)
Metadata	Table 4	2,502	1	2,502
Geolocation and Viewing Geometry	Table 5	48	4,155	199,440
Layer Descriptor	Table 6	608	4,155	2,526,240
Layer Optical Properties	Table 7	1,320	4,155	5,484,600
Total Bytes/Granule (Mode 7.2)		**4,478**		**8,212,782**

Table 3: CATS-ISS Metadata Record (1 per granule)

Parameter	Data Type	Units	Nominal Range	Elem/ Granule	Bytes
Product ID	Char	N/A		1	40
Product_Version_Number	Char	N/A		1	40
Product_Creation_Date	Char	N/A		1	40
Product_Creator	Char	N/A		1	40
Granule_Start_DateTime	Char	N/A		1	40
Granule_Stop_DateTime	Char	N/A		1	40
Granule_Production_DateTime	Char	N/A		1	40
Granule_Start_Latitude	Float	deg		1	4
Granule_Start_Longitude	Float	deg		1	4
Granule_Stop_Latitude	Float	deg		1	4
Granule_Stop_Longitude	Float	deg		1	4
Granule_Start_RDM	Float	N/A		1	4
Granule_Stop_RDM	Float	N/A		1	4
Number_5km_Profiles	Ulong	N/A		1	4
Horizontal_Resolution	Int	km		1	2
Number_Bins	Int	N/A		1	2
Max_Number_Layers	Int	N/A		1	2
Bin_Size	Float	km		1	4
*Percent_Profiles_Bad	Float	%		2	8
Bin_Altitude_Array	Float	km	-2, 30	534	2136
L1_Input_Version_Number	Char	N/A		1	40
Total Bytes/Granule (All Modes)					**2502**

*These are 2 element arrays for left FOV (1) and right FOV(2)

Table 4: CATS-ISS Layer Geolocation and Viewing Geometry Record

Parameter	Data Type	Units	Nominal Range	Elem/Rec	Bytes
CATS_Left_FOV_Latitude	Float	deg	-60 - 60	3	12
CATS_Left_FOV_Longitude	Float	deg	-180 - 180	3	12
CATS_Right_FOV_Latitude	Float	deg	-60 - 60	3	12
CATS_Right_FOV_Longitude	Float	deg	-180 - 180	3	12
CATS_Fore_FOV_Latitude	Float	deg	-60 - 60	3	12
CATS_Fore_FOV_Longitude	Float	deg	-180 - 180	3	12
CATS_Left_FOV_Angle	Float	deg	-10 - 10	3	12
CATS_Right_FOV_Angle	Float	deg	-10 - 10	3	12
CATS_Fore_FOV_Angle	Float	deg	-10 - 10	3	12
Index_Top_Bin_Left_FOV	Float	km	0 - 100	1	4
Index_Top_Bin_Right_FOV	Float	km	0 - 100	1	4
Index_Top_Bin_Fore_FOV	Float	km	0 - 100	1	4
Solar_Azimuth_Angle	Float	deg	-10 - 10	1	4
Solar_Zenith_Angle	Float	deg	-10 - 10	1	4
Total Bytes/Rec Mode 7.1					**84**
Total Bytes/Rec Mode 7.2					**48**

Nominal Granule will span roughly 45 minutes (1/2 orbit) or 2700 seconds

Table 5: CATS-ISS Layer Descriptor Record

Parameter	Data Type	Units	Nominal Range	Elem/ Rec	Bytes
Profile_UTC_Date	Long			1	8
Profile_UTC_Time	double			3	16
Profile_ID	ULong			1	8
Day_Night_Flag	Byte	N/A	0-1	1	2
Surface_Type_Left_FOV	Byte	N/A		1	2
Surface_Type_Right_FOV	Byte	N/A		1	2
Surface_Type_Fore_FOV	Byte	N/A		1	2

Lidar_Surface_Altitude_Left_FOV	Float	km	0-6	1	4
Lidar_Surface_Altitude_Right_FOV	Float	km	0-6	1	4
Lidar_Surface_Altitude_Fore_FOV	Float	km	0-6	1	4
DEM_Surface_Altitude_Left_FOV	Float	km	0-6	1	4
DEM_Surface_Altitude_Right_FOV	Float	km	0-6	1	4
DEM_Surface_Altitude_Fore_FOV	Float	km	0-6	1	4
Sky_Condition_Left_FOV	Integer	N/A	0-3	1	2
Sky_Condition_Right_FOV	Integer	N/A	0-3	1	2
Sky_Condition_Fore_FOV	Integer	N/A	0-3	1	2
Number_Layers_Left_FOV	Integer	N/A	0-10	1	2
Number_Layers_Right_FOV	Integer	N/A	0-10	1	2
Number_Layers_Fore_FOV	Integer	N/A	0-10	1	2
Layer_Top_Bin_Left_FOV	Integer	N/A	0-533	10	20
Layer_Top_Bin _Right_FOV	Integer	N/A	0-533	10	20
Layer_Top_Bin_Fore_FOV	Integer	N/A	0-533	10	20
Layer_Top_Altitude_Left_FOV	Float	km	0-23	10	40
Layer_Top_Altitude_Right_FOV	Float	km	0-23	10	40
Layer_Top_Altitude_Fore_FOV	Float	km	0-23	10	40
Layer_Base_Bin_Left_FOV	Integer	N/A	0-533	10	20
Layer_Base_Bin _Right_FOV	Integer	N/A	0-533	10	20
Layer_Base_Bin_Fore_FOV	Integer	N/A	0-533	10	20
Layer_Base_Altitude_Left_FOV	Float	km	0-23	10	40
Layer_Base_Altitude_Right_FOV	Float	km	0-23	10	40
Layer_Base_Altitude_Fore_FOV	Float	km	0-23	10	40
Layer_Top_Temperature_Left_FOV	Float	C	-110-60	10	40
Layer_Top_Temperature_Right_FOV	Float	C	-110-60	10	40
Layer_Top_Temperature_Fore_FOV	Float	C	-110-60	10	40
Layer_Base_Temperature_Left_FOV	Float	C	-110-60	10	40
Layer_Base_Temperature _Right_FOV	Float	C	-110-60	10	40
Layer_Base_Temperature_Fore_FOV	Float	C	-110-60	10	40
Layer_Top_Pressure_Left_FOV	Float	hPa	1-1080	10	40
Layer_Top_Pressure_Right_FOV	Float	hPa	1-1080	10	40
Layer_Top_Pressure_Fore_FOV	Float	hPa	1-1080	10	40
Layer_Base_Pressure_Left_FOV	Float	hPa	1-1080	10	40
Layer_Base_Pressure _Right_FOV	Float	hPa	1-1080	10	40
Layer_Base_Pressure_Fore_FOV	Float	hPa	1-1080	10	40
Opacity_Left_FOV	Integer	N/A	0-1	10	20
Opacity_Right_FOV	Integer	N/A	0-1	10	20
Opacity_Fore_FOV	Integer	N/A	0-1	10	20
Feature_Type_Left_FOV	Integer	N/A	0-3	10	20
Feature_Type_Right_FOV	Integer	N/A	0-3	10	20
Feature_Type_Fore_FOV	Integer	N/A	0-3	10	20
Feature_Type_Score_Left_FOV	Integer	N/A	-10-10	10	20

Feature_Type_Score_Right_FOV	Integer	N/A	-10-10	10	20
Feature_Type_Score_Fore_FOV	Integer	N/A	-10-10	10	20
Cloud_Phase_Left_FOV	Integer	N/A	0-3	10	20
Cloud_Phase_Right_FOV	Integer	N/A	0-3	10	20
Cloud_Phase_Fore_FOV	Integer	N/A	0-3	10	20
Cloud_Phase_Score_Left_FOV	Integer	N/A	-10-10	10	20
Cloud_Phase_Score_Right_FOV	Integer	N/A	-10-10	10	20
Cloud_Phase_Score_Fore_FOV	Integer	N/A	-10-10	10	20
Aerosol_Type_Left_FOV	Integer	N/A	0-8	10	20
Aerosol_Type_Right_FOV	Integer	N/A	0-8	10	20
Aerosol_Type_Fore_FOV	Integer	N/A	0-8	10	20
Extinction_QC_Flag_532_Left_FOV	Integer	N/A	-1-9	10	20
Extinction_QC_Flag_532_Right_FOV	Integer	N/A	-1-9	10	20
Extinction_QC_Flag_1064_Left_FOV	Integer	N/A	-1-9	10	20
Extinction_QC_Flag_1064_Right_FOV	Integer	N/A	-1-9	10	20
Extinction_QC_Flag_1064_Fore_FOV	Integer	N/A	-1-9	10	20
Lidar_Ratio_Selection_Method_532_Left_FOV	Integer	N/A	0-9	10	20
Lidar_Ratio_Selection_Method_532_Right_FOV	Integer	N/A	0-9	10	20
Lidar_Ratio_Selection_Method_1064_Left_FOV	Integer	N/A	0-9	10	20
Lidar_Ratio_Selection_Method_1064_Right_FOV	Integer	N/A	0-9	10	20
Lidar_Ratio_Selection_Method_1064_Fore_FOV	Integer	N/A	0-9	10	20
Layer_Effective_Multiple_Scattering_Factor_532_Left_FOV	Float	N/A	0-1.0	10	40
Layer_Effective_Multiple_Scattering_Factor_532_Right_FOV	Float	N/A	0-1.0	10	40
Layer_Effective_Multiple_Scattering_Factor_1064_Left_FOV	Float	N/A	0-1.0	10	40
Layer_Effective_Multiple_Scattering_Factor_1064_Right_FOV	Float	N/A	0-1.0	10	40
Layer_Effective_Multiple_Scattering_Factor_1064_Fore_FOV	Float	N/A	0-1.0	10	40
Constrained_Lidar_Ratio_Flag	Integer	N/A	0-9	40	80
Total Bytes/Rec Mode 7.1					**1262**
Total Bytes/Rec Mode 7.2					**608**

Table 6: CATS-ISS Layer Optical Properties

Parameter	Data Type	Units	Nominal Range	Elem/ Rec	Bytes
Attenuated_Backscatter_Statistics_532_Left_FOV	Float	$km^{-1}sr^{-1}$	N/A	40	160
Attenuated_Backscatter_Statistics_532_Right_FOV	Float	$km^{-1}sr^{-1}$	N/A	40	160
Attenuated_Backscatter_Statistics_532_Fore_FOV	Float	$km^{-1}sr^{-1}$	N/A	40	160
Integrated_Attenuated_Backscatter_532_Left_FOV	Float	sr^{-1}	0-1.8	10	40
Integrated_Attenuated_Backscatter_532_Right_FOV	Float	sr^{-1}	0-1.8	10	40
Integrated_Attenuated_Backscatter_532_Fore_FOV	Float	sr^{-1}	0-1.8	10	40
Integrated_Attenuated_Backscatter_Uncertainty_532_Left_FOV	Float	sr^{-1}	0-0.5	10	40
Integrated_Attenuated_Backscatter_Uncertainty_532_Right_FOV	Float	sr^{-1}	0-0.5	10	40
Integrated_Attenuated_Backscatter_Uncertainty_532_Fore_FOV	Float	sr^{-1}	0-0.5	10	40
Attenuated_Backscatter_Statistics_1064_Left_FOV	Float	$km^{-1}sr^{-1}$	N/A	40	160
Attenuated_Backscatter_Statistics_1064_Right_FOV	Float	$km^{-1}sr^{-1}$	N/A	40	160
Attenuated_Backscatter_Statistics_1064_Fore_FOV	Float	$km^{-1}sr^{-1}$	N/A	40	160
Integrated_Attenuated_Backscatter_1064_Left_FOV	Float	sr^{-1}	0-1.8	10	40
Integrated_Attenuated_Backscatter_1064_Right_FOV	Float	sr^{-1}	0-1.8	10	40
Integrated_Attenuated_Backscatter_1064_Fore_FOV	Float	sr^{-1}	0-1.8	10	40
Integrated_Attenuated_Backscatter_Uncertainty_1064_Left_FOV	Float	sr^{-1}	0-0.5	10	40
Integrated_Attenuated_Backscatter_Uncertainty_1064_Right_FOV	Float	sr^{-1}	0-0.5	10	40
Integrated_Attenuated_Backscatter_Uncertainty_1064_Fore_FOV	Float	sr^{-1}	0-0.5	10	40
Volume_Depolarization_Ratio_Statistics_532_Left_FOV	Float	N/A	N/A	40	160
Volume_Depolarization_Ratio_Statistics_532_	Float	N/A	N/A	40	160

Right_FOV					
Integrated_Volume_Depolarization_Ratio_532_Left_FOV	Float	N/A	0-1.0	10	40
Integrated_Volume_Depolarization_Ratio_532_Right_FOV	Float	N/A	0-1.0	10	40
Integrated_Volume_Depolarization_Ratio_Uncertainty_532_Left_FOV	Float	N/A	0-2.0	10	40
Integrated_Volume_Depolarization_Ratio_Uncertainty_532_Right_FOV	Float	N/A	0-2.0	10	40
Volume_Depolarization_Ratio_Statistics_1064_Left_FOV	Float	N/A	N/A	40	160
Volume_Depolarization_Ratio_Statistics_1064_Right_FOV	Float	N/A	N/A	40	160
Volume_Depolarization_Ratio_Statistics_1064_Fore_FOV	Float	N/A	N/A	40	160
Integrated_Volume_Depolarization_Ratio_1064_Left_FOV	Float	N/A	0-1.0	10	40
Integrated_Volume_Depolarization_Ratio_1064_Right_FOV	Float	N/A	0-1.0	10	40
Integrated_Volume_Depolarization_Ratio_1064_Fore_FOV	Float	N/A	0-1.0	10	40
Integrated_Volume_Depolarization_Ratio_Uncertainty_1064_Left_FOV	Float	N/A	0-2.0	10	40
Integrated_Volume_Depolarization_Ratio_Uncertainty_1064_Right_FOV	Float	N/A	0-2.0	10	40
Integrated_Volume_Depolarization_Ratio_Uncertainty_1064_Fore_FOV	Float	N/A	0-2.0	10	40
Spectral_Depolarization_Ratio_Statistics_Left_FOV	Float	N/A	N/A	40	160
Spectral_Depolarization_Ratio_Statistics_Right_FOV	Float	N/A	N/A	40	160
Integrated_Spectral_Depolarization_Ratio_Left_FOV	Float	N/A	0-1.0	10	40
Integrated_Spectral_Depolarization_Ratio_Right_FOV	Float	N/A	0-1.0	10	40
Integrated_Spectral_Depolarization_Ratio_Uncertainty_Left_FOV	Float	N/A	0-2.0	10	40
Integrated_Spectral_Depolarization_Ratio_Uncertainty_Right_FOV	Float	N/A	0-2.0	10	40
Attenauted_Total_Color_Ratio_Statistics_Left_FOV	Float	N/A	N/A	40	160
Attenauted_Total_Color_Ratio_Statistics_Right_FOV	Float	N/A	N/A	40	160
Attenauted_Total_Color_Ratio_Statistics_Fore_FOV	Float	N/A	N/A	40	160

Integrated_Attenauted_Total_Color_Ratio_Left_FOV	Float	N/A	0-2.0	10	40
Integrated_Attenauted_Total_Color_Ratio_Right_FOV	Float	N/A	0-2.0	10	40
Integrated_Attenauted_Total_Color_Ratio_Fore_FOV	Float	N/A	0-2.0	10	40
Integrated_Attenauted_Total_Color_Ratio_Uncertainty_Left_FOV	Float	N/A	0-3.0	10	40
Integrated_Attenauted_Total_Color_Ratio_Uncertainty_Right_FOV	Float	N/A	0-3.0	10	40
Integrated_Attenauted_Total_Color_Ratio_Uncertainty_Fore_FOV	Float	N/A	0-3.0	10	40
Measured_Two_Way_Transmittance_532_Left_FOV	Float	N/A	0-1.0	10	40
Measured_Two_Way_Transmittance_532_Right_FOV	Float	N/A	0-1.0	10	40
Measured_Two_Way_Transmittance_Uncertainty_532_Left_FOV	Float	N/A	0-2.0	10	40
Measured_Two_Way_Transmittance_Uncertainty_532_Right_FOV	Float	N/A	0-2.0	10	40
Measured_Two_Way_Transmittance_1064_Left_FOV	Float	N/A	0-1.0	10	40
Measured_Two_Way_Transmittance_1064_Right_FOV	Float	N/A	0-1.0	10	40
Measured_Two_Way_Transmittance_1064_Fore_FOV	Float	N/A	0-1.0	10	40
Measured_Two_Way_Transmittance_Uncertainty_1064_Left_FOV	Float	N/A	0-2.0	10	40
Measured_Two_Way_Transmittance_Uncertainty_1064_Right_FOV	Float	N/A	0-2.0	10	40
Measured_Two_Way_Transmittance_Uncertainty_1064_Fore_FOV	Float	N/A	0-2.0	10	40
Two_Way_Transmittance_Measurement_Region_Left_FOV	Float	km	0-30	20	80
Two_Way_Transmittance_Measurement_Region_Right_FOV	Float	km	0-30	20	80
Two_Way_Transmittance_Measurement_Region_Fore_FOV	Float	km	0-30	20	80
Feature_Optical_Depth_532_Left_FOV	Float	N/A	0-3.0	10	40
Feature_Optical_Depth_532_Right_FOV	Float	N/A	0-3.0	10	40
Feature_Optical_Depth_Uncertainty_532_Left_FOV	Float	N/A	0-3.0	10	40
Feature_Optical_Depth_Uncertainty_532_Right_FOV	Float	N/A	0-3.0	10	40
Feature_Optical_Depth_1064_Left_FOV	Float	N/A	0-3.0	10	40

Feature_Optical_Depth_1064_Right_FOV	Float	N/A	0-3.0	10	40
Feature_Optical_Depth_1064_Fore_FOV	Float	N/A	0-3.0	10	40
Feature_Optical_Depth_Uncertainty_1064_Left_FOV	Float	N/A	0-3.0	10	40
Feature_Optical_Depth_Uncertainty_1064_Right_FOV	Float	N/A	0-3.0	10	40
Feature_Optical_Depth_Uncertainty_1064_Fore_FOV	Float	N/A	0-3.0	10	40
Lidar_Ratio_532_Left_FOV	Float	sr	0-100.0	10	40
Lidar_Ratio_532_Right_FOV	Float	sr	0-100.0	10	40
Lidar_Ratio_1064_Left_FOV	Float	sr	0-100.0	10	40
Lidar_Ratio_1064_Right_FOV	Float	sr	0-100.0	10	40
Lidar_Ratio_1064_Fore_FOV	Float	sr	0-100.0	10	40
Ice_Water_Path_532_Left_FOV	Float	g/m^2	0-200.0	10	40
Ice_Water_Path_532_Right_FOV	Float	g/m^2	0-200.0	10	40
Ice_Water_Path_532_Uncertainty_Left_FOV	Float	g/m^2	0-99.99	10	40
Ice_Water_Path_532_Uncertainty_Right_FOV	Float	g/m^2	0-99.99	10	40
Ice_Water_Path_1064_Left_FOV	Float	g/m^2	0-200.0	10	40
Ice_Water_Path_1064_Right_FOV	Float	g/m^2	0-200.0	10	40
Ice_Water_Path_1064_Fore_FOV	Float	g/m^2	0-200.0	10	40
Ice_Water_Path_1064_Uncertainty_Left_FOV	Float	g/m^2	0-99.99	10	40
Ice_Water_Path_1064_Uncertainty_Right_FOV	Float	g/m^2	0-99.99	10	40
Ice_Water_Path_1064_Uncertainty_Fore_FOV	Float	g/m^2	0-99.99	10	40
Total Bytes/Rec Mode 7.1					**4160**
Total Bytes/Rec Mode 7.2					**1320**

Table 7: Definitions of CATS Vertical Feature Mask Parameters

Parameter	Interpretation
Sky_Condition	0 = clean skies (no clouds/aerosols) 1 = clear skies (no clouds) 2 = cloudy skies (no aerosols) 3 = hazy/cloudy (both clouds/aerosols)
Feature_Type	0 = invalid 1 = cloud 2 = undetermined 3 = aerosol
Feature_Type_Score	| 10 | = high confidence | 1 | = low confidence 0 = zero confidence
Cloud_Phase	0 = invalid 1 = water cloud 2 = unknown cloud phase 3 = ice cloud
Cloud_Phase_Score	| 10 | = high confidence | 1 | = low confidence 0 = zero confidence
Aerosol_Type	0 = invalid 1 = marine 2 = marine mixture 3 = dust 4 = dust mixture 5 = clean/background 6 = polluted continental 7 = smoke 8 = volcanic

Table 8: Definition of CATS Optical Properties Flags

Parameter	Interpretation
Extinction_QC_Flag	-1=calculation not attempted 0 = layer extinction analysis nominal 1 = layer hit earth's surface before layer bottom reached, adjusted bottom 2 = Tp_sq below min, lowering lidar ratio thru iteration process 3 = Tp_sq above max, raising lidar ratio thru iteration process 4 = # of iterations maxed out 5 = signal inside layer saturated before bottom 6 = layer is opaque, layer OD= -1 7 = open slot (not used) 8 = layer OD out of bounds (invalid) OD= -999.99 9 = layer OD invalid because final lidar ratio out of bounds
Lidar_Ratio_Selection_Method	0 = generic default 1 = aerosol GEOS5 lookup table 2 = cloud lookup table 3 = 1064 lidar ratio used 532 OD (for ice clouds only) 4 = constrained result using clear zone just below layer 5 = constrained result with opaque layer 6 = lowered lidar ratio by a max of 15sr to reach layer bottom 7 = raised lidar ratio by a max of 15sr to reach layer bottom 8 = open slot (not used) 9 = missing
Constrained_Lidar_Ratio_Flag	0 = useful value using nominal "constrained' procedure 1 = useful value using opaque "constrained' procedure 2 = constrained lidar ratio outside thresholds 3 = below layer clear zone too small 4 = clear zone signal error > threshold 5 = Tp_sq < allowed min 6 = Tp_sq at or below 0.0 7 = useful 1064 lidar ratio using 532 OD (for ice clouds only) 8 = Tp_sq at or below 0.0 in opaque cloud conditions 9 = missing

2.4 Lidar Level 2 Operation Profile DP

In the following tables, the parameters listed in black font will always be on the product regardless of operating mode. Red font denotes mode 7.1 only and blue font mode 7.2 only.

February 12, 2016 V1.02_ Corresponds to V1_02 L2 Product Software

Data File Name:
5 km Profile: CATS-ISS_L2O_N-M7.1-V1-02_05kmPro.2014-09-17T00-31-01UTC.hdf5

Table 1: CATS-ISS 5 km Profile Record Summary for Mode 7.1

Record Name	Reference Table	Record Size (Bytes)	Records/ File	File Size (Bytes)
Metadata	Table 4	2,500	1	2,500
Geolocation and Viewing Geometry	Table 5	84	4,155	2,326,800
5 km Profile	Table 6	106,754	4,155	443,562,870
Total Bytes/Granule (Mode 7.1)		**109,814**		**445,892,170**

Table 2: CATS-ISS 5 km Profile Record Summary for Mode 7.2

Record Name	Referenc e Table	Record Size (Bytes)	Records/ File	File Size (Bytes)
Metadata	Table 4	2,500	1	2,500
Geolocation and Viewing Geometry	Table 5	48	4,155	2,326,800
5 km Profile	Table 6	36,106	4,155	133,400,430
Total Bytes/Granule (Mode 7.2)		**39,166**		**135,729,730**

Table 3: CATS-ISS Metadata Record (1 per granule)

Parameter	Data Type	Units	Nominal Range	Elem/ Granule	Bytes
Product ID	Char	N/A		1	40
Product_Version_Number	Char	N/A		1	40
L1_Input_Version_Number	Char	N/A		1	40
Product_Creation_Date	Char	N/A		1	40
Product_Creator	Char	N/A		1	40
Granule_Start_DateTime	Char	N/A		1	40
Granule_Stop_DateTime	Char	N/A		1	40
Granule_Production_DateTime	Char	N/A		1	40
Granule_Start_Latitude	Float	deg		1	4
Granule_Start_Longitude	Float	deg		1	4
Granule_Stop_Latitude	Float	deg		1	4
Granule_Stop_Longitude	Float	deg		1	4
Granule_Start_RDM	Float	N/A		1	4
Granule_Stop_RDM	Float	N/A		1	4
Number_5km_Profiles	Ulong	N/A		1	4
Horizontal_Resolution	Int	km	5	1	2
Number_Bins	Int	N/A	534	1	2
Bin_Size	Float	km		1	4
*Percent_Profiles_Bad	Float	%		2	8
Bin_Altitude_Array	Float	km	-2, 30	534	2136
Total Bytes/Granule (All Modes)					**2500**

*These are 2 element arrays for left FOV (1) and right FOV(2)

Table 4: CATS-ISS Profile Geolocation and Viewing Geometry Record

Parameter	Data Type	Units	Nominal Range	Elem/Rec	Bytes
CATS_Left_FOV_Latitude	Float	deg	-60 - 60	3	12
CATS_Left_FOV_Longitude	Float	deg	-180 - 180	3	12
CATS_Right_FOV_Latitude	Float	deg	-60 - 60	3	12
CATS_Right_FOV_Longitude	Float	deg	-180 - 180	3	12
CATS_Fore_FOV_Latitude	Float	deg	-60 - 60	3	12
CATS_Fore_FOV_Longitude	Float	deg	-180 - 180	3	12
CATS_Left_FOV_Angle	Float	deg	-10 - 10	3	12
CATS_Right_FOV_Angle	Float	deg	-10 - 10	3	12
CATS_Fore_FOV_Angle	Float	deg	-10 - 10	3	12
Index_Top_Bin_Left_FOV	Float	km	0 - 100	1	4
Index_Top_Bin_Right_FOV	Float	km	0 - 100	1	4
Index_Top_Bin_Fore_FOV	Float	km	0 - 100	1	4
Solar_Azimuth_Angle	Float	deg	-10 - 10	1	4
Solar_Zenith_Angle	Float	deg	-10 - 10	1	4
Total Bytes/Rec Mode 7.1					**84**
Total Bytes/Rec Mode 7.2					**48**

Nominal Granule will span roughly 45 minutes (1/2 orbit) or 2700 seconds

Table 5: CATS-ISS 5 km Profile Record

Parameter	Data Type	Units	Nominal Range	Elem/ Rec	Bytes
Profile_UTC_Date	Long			1	8
Profile_UTC_Time	double			3	48
Profile_ID	ULong			1	8
Day_Night_Flag	Byte	N/A	0-1	1	2
Surface_Type_Left_FOV	Byte	N/A		1	2
Surface_Type_Right_FOV	Byte	N/A		1	2
Surface_Type_Fore_FOV	Byte	N/A		1	2
Lidar_Surface_Altitude_Left_FOV	Float	km	0-6	1	4
Lidar_Surface_Altitude_Right_FOV	Float	km	0-6	1	4
Lidar_Surface_Altitude_Fore_FOV	Float	km	0-6	1	4
DEM_Surface_Altitude_Left_FOV	Float	km	0-6	1	4
DEM_Surface_Altitude_Right_FOV	Float	km	0-6	1	4
DEM_Surface_Altitude_Fore_FOV	Float	km	0-6	1	4
Sky_Condition_Left_FOV	Integer	N/A	0-3	1	2
Sky_Condition_Right_FOV	Integer	N/A	0-3	1	2
Sky_Condition_Fore_FOV	Integer	N/A	0-3	1	2

Atmospheric_Temperature	Float	C	-120-60	533	2132
Atmospheric_Pressure	Float	hPa	1-1080	533	2132
Atmospheric_Relative Humidity	Float	%	0-100	533	2132
Surface_Wind_Velocity	Float	m/s	-80-80	2	8
Wind_Velocity_10m	Float	m/s	-80-80	2	8
Tropopause_Height	Float	km	6-20	1	4
Tropopause_Temperature	Float	C	-120-60	1	4
Feature_Type_Left_FOV	Integer	N/A	0-3	533	1066
Feature_Type_Right_FOV	Integer	N/A	0-3	533	1066
Feature_Type_Fore_FOV	Integer	N/A	0-3	533	1066
Feature_Type_Score_Left_FOV	Integer	N/A	-10-10	533	1066
Feature_Type_Score_Right_FOV	Integer	N/A	-10-10	533	1066
Feature_Type_Score_Fore_FOV	Integer	N/A	-10-10	533	1066
Cloud_Phase_Left_FOV	Integer	N/A	0-3	533	1066
Cloud_Phase_Right_FOV	Integer	N/A	0-3	533	1066
Cloud_Phase_Fore_FOV	Integer	N/A	0-3	533	1066
Cloud_Phase_Score_Left_FOV	Integer	N/A	-10-10	533	1066
Cloud_Phase_Score_Right_FOV	Integer	N/A	-10-10	533	1066
Cloud_Phase_Score_Fore_FOV	Integer	N/A	-10-10	533	1066
Aerosol_Type_Left_FOV	Integer	N/A	0-8	533	1066
Aerosol_Type_Right_FOV	Integer	N/A	0-8	533	1066
Aerosol_Type_Fore_FOV	Integer	N/A	0-8	533	1066
Extinction_QC_Flag_532_Left_FOV	Integer	N/A	0-8	533	1066
Extinction_QC_Flag_532_Right_FOV	Integer	N/A	0-8	533	1066
Extinction_QC_Flag_1064_Left_FOV	Integer	N/A	0-8	533	1066
Extinction_QC_Flag_1064_Right_FOV	Integer	N/A	0-8	533	1066
Extinction_QC_Flag_1064_Fore_FOV	Integer	N/A	0-8	533	1066
Particulate_Backscatter_Coefficient_532_Left_FOV	Float	$km^{-1}sr^{-1}$	0-1.8	533	2132
Particulate_Backscatter_Coefficient_532_Right_FOV	Float	$km^{-1}sr^{-1}$	0-1.8	533	2132
Particulate_Backscatter_Coefficient_Uncertainty_532_Left_FOV	Float	$km^{-1}sr^{-1}$	0-0.5	533	2132
Particulate_Backscatter_Coefficient_Uncertainty_532_Right_FOV	Float	$km^{-1}sr^{-1}$	0-0.5	533	2132
Particulate_Backscatter_Coefficient_1064_Left_FOV	Float	$km^{-1}sr^{-1}$	0-1.8	533	2132
Particulate_Backscatter_Coefficient_1064_Right_FOV	Float	$km^{-1}sr^{-1}$	0-1.8	533	2132
Particulate_Backscatter_Coefficient_1064_Fore_FOV	Float	$km^{-1}sr^{-1}$	0-1.8	533	2132
Particulate_Backscatter_Coefficient_Uncertainty_1064_Left_FOV	Float	$km^{-1}sr^{-1}$	0-0.5	533	2132
Particulate_Backscatter_Coefficient_Uncertaint	Float	km-	0-0.5	533	2132

y_1064_Right_FOV		$^{1}sr^{-1}$			
Particulate_Backscatter_Coefficient_Uncertainty_1064_Fore_FOV	Float	$km^{-1}sr^{-1}$	0-0.5	533	2132
Total_Depolarization_Ratio_532_Left_FOV	Float	N/A	0-1.0	533	2132
Total_Depolarization_Ratio_532_Right_FOV	Float	N/A	0-1.0	533	2132
Total_Depolarization_Ratio_Uncertainty_532_Left_FOV	Float	N/A	0-2.0	533	2132
Total_Depolarization_Ratio_Uncertainty_532_Right_FOV	Float	N/A	0-2.0	533	2132
Total_Depolarization_Ratio_1064_Left_FOV	Float	N/A	0-1.0	533	2132
Total_Depolarization_Ratio_1064_Right_FOV	Float	N/A	0-1.0	533	2132
Total_Depolarization_Ratio_1064_Fore_FOV	Float	N/A	0-1.0	533	2132
Total_Depolarization_Ratio_Uncertainty_1064_Left_FOV	Float	N/A	0-2.0	533	2132
Total_Depolarization_Ratio_Uncertainty_1064_Right_FOV	Float	N/A	0-2.0	533	2132
Total_Depolarization_Ratio_Uncertainty_1064_Fore_FOV	Float	N/A	0-2.0	533	2132
Extinction_Coefficient_532_Left_FOV	Float	km^{-1}	0-1.25	533	2132
Extinction_Coefficient_532_Right_FOV	Float	km^{-1}	0-1.25	533	2132
Extinction_Coefficient_Uncertainty_532_Left_FOV	Float	km^{-1}	0-2	533	2132
Extinction_Coefficient_Uncertainty_532_Right_FOV	Float	km^{-1}	0-2	533	2132
Extinction_Coefficient_1064_Left_FOV	Float	km^{-1}	0-1.25	533	2132
Extinction_Coefficient_1064_Right_FOV	Float	km^{-1}	0-1.25	533	2132
Extinction_Coefficient_1064_Fore_FOV	Float	km^{-1}	0-1.25	533	2132
Extinction_Coefficient_Uncertainty_1064_Left_FOV	Float	km^{-1}	0-2	533	2132
Extinction_Coefficient_Uncertainty_1064_Right_FOV	Float	km^{-1}	0-2	533	2132
Extinction_Coefficient_Uncertainty_1064_Fore_FOV	Float	km^{-1}	0-2	533	2132
Column_Optical_Depth_532_Left_FOV	Float	N/A	0-3.0	1	4
Column_Optical_Depth_532_Right_FOV	Float	N/A	0-3.0	1	4
Column_Optical_Depth_Uncertainty_532_Left_FOV	Float	N/A	0-3.0	1	4
Column_Optical_Depth_Uncertainty_532_Right_FOV	Float	N/A	0-3.0	1	4
Column_Optical_Depth_1064_Left_FOV	Float	N/A	0-3.0	1	4
Column_Optical_Depth_1064_Right_FOV	Float	N/A	0-3.0	1	4
Column_Optical_Depth_1064_Fore_FOV	Float	N/A	0-3.0	1	4
Column_Optical_Depth_Uncertainty_1064_Left_FOV	Float	N/A	0-3.0	1	4

Column_Optical_Depth_Uncertainty_1064_Right_FOV	Float	N/A	0-3.0	1	4
Column_Optical_Depth_Uncertainty_1064_Fore_FOV	Float	N/A	0-3.0	1	4
Cloud_Optical_Depth_532_Left_FOV	Float	N/A	0-3.0	1	4
Cloud_Optical_Depth_532_Right_FOV	Float	N/A	0-3.0	1	4
Cloud_Optical_Depth_Uncertainty_532_Left_FOV	Float	N/A	0-3.0	1	4
Cloud_Optical_Depth_Uncertainty_532_Right_FOV	Float	N/A	0-3.0	1	4
Cloud_Optical_Depth_1064_Left_FOV	Float	N/A	0-3.0	1	4
Cloud_Optical_Depth_1064_Right_FOV	Float	N/A	0-3.0	1	4
Cloud_Optical_Depth_1064_Fore_FOV	Float	N/A	0-3.0	1	4
Cloud_Optical_Depth_Uncertainty_1064_Left_FOV	Float	N/A	0-3.0	1	4
Cloud_Optical_Depth_Uncertainty_1064_Right_FOV	Float	N/A	0-3.0	1	4
Cloud_Optical_Depth_Uncertainty_1064_Fore_FOV	Float	N/A	0-3.0	1	4
Aerosol_Optical_Depth_532_Left_FOV	Float	N/A	0-3.0	1	4
Aerosol_Optical_Depth_532_Right_FOV	Float	N/A	0-3.0	1	4
Aerosol_Optical_Depth_Uncertainty_532_Left_FOV	Float	N/A	0-3.0	1	4
Aerosol_Optical_Depth_Uncertainty_532_Right_FOV	Float	N/A	0-3.0	1	4
Aerosol_Optical_Depth_1064_Left_FOV	Float	N/A	0-3.0	1	4
Aerosol_Optical_Depth_1064_Right_FOV	Float	N/A	0-3.0	1	4
Aerosol_Optical_Depth_1064_Fore_FOV	Float	N/A	0-3.0	1	4
Aerosol_Optical_Depth_Uncertainty_1064_Left_FOV	Float	N/A	0-3.0	1	4
Aerosol_Optical_Depth_Uncertainty_1064_Right_FOV	Float	N/A	0-3.0	1	4
Aerosol_Optical_Depth_Uncertainty_1064_Fore_FOV	Float	N/A	0-3.0	1	4
Ice_Water_Content_532_Left_FOV	Float	g/m^2	0-1.0	533	2132
Ice_Water_Content_532_Right_FOV	Float	g/m^2	0-1.0	533	2132
Ice_Water_Content_532_Uncertainty_Left_FOV	Float	g/m^2	0-99.99	533	2132
Ice_Water_Content_532_Uncertainty_Right_FOV	Float	g/m^2	0-99.99	533	2132
Ice_Water_Content_1064_Left_FOV	Float	g/m^2	0-1.0	533	2132
Ice_Water_Content_1064_Right_FOV	Float	g/m^2	0-1.0	533	2132
Ice_Water_Content_1064_Fore_FOV	Float	g/m^2	0-1.0	533	2132
Ice_Water_Content_1064_Uncertainty_Left_FOV	Float	g/m^2	0-99.99	533	2132

Ice_Water_Content_1064_Uncertainty_Right_FOV	Float	g/m^2	0-99.99	533	2132
Ice_Water_Content_1064_Uncertainty_Fore_FOV	Float	g/m^2	0-99.99	533	2132
Multiple_Scattering_Factor_532_Left_FOV	Float	N/A	0-1.0	533	2132
Multiple_Scattering_Factor_532_Right_FOV	Float	N/A	0-1.0	533	2132
Multiple_Scattering_Factor_1064_Left_FOV	Float	N/A	0-1.0	533	2132
Multiple_Scattering_Factor_1064_Right_FOV	Float	N/A	0-1.0	533	2132
Multiple_Scattering_Factor_1064_Fore_FOV	Float	N/A	0-1.0	533	2132
Total Bytes/Rec Mode 7.1					**106754**
Total Bytes/Rec Mode 7.2					**32106**

Table 6: Definitions of CATS Vertical Feature Mask Parameters

Parameter	Interpretation
Sky_Condition	0 = clean skies (no clouds/aerosols) 1 = clear skies (no clouds) 2 = cloudy skies (no aerosols) 3 = hazy/cloudy (both clouds/aerosols)
Feature_Type	0 = invalid 1 = cloud 2 = undetermined 3 = aerosol 4 = no signal (attenuated)
Feature_Type_Score	| 10 | = high confidence | 1 | = low confidence 0 = zero confidence
Cloud_Phase	0 = invalid 1 = water cloud 2 = unknown cloud phase 3 = ice cloud
Cloud_Phase_Score	| 10 | = high confidence | 1 | = low confidence 0 = zero confidence
Aerosol_Type	0 = invalid 1 = marine 2 = marine mixture 3 = dust 4 = dust mixture 5 = clean/background 6 = polluted continental 7 = smoke 8 = volcanic

Table 7: Definition of CATS Optical Properties Flags

Parameter	Interpretation
Extinction_QC_Flag	-1=calculation not attempted 0 = layer extinction analysis nominal 1 = layer hit earth's surface before layer bottom reached, adjusted bottom 2 = Tp_sq below min, lowering lidar ratio thru iteration process 3 = Tp_sq above max, raising lidar ratio thru iteration process 4 = # of iterations maxed out 5 = signal inside layer saturated before bottom 6 = layer is opaque, layer OD= -1 7 = open slot (not used) 8 = layer OD out of bounds (invalid) OD= -999.99 9 = layer OD invalid because final lidar ratio out of bounds

2.5 Lidar Level 2 Operational Near Real Time

The CATS NRT data product began production in May 2015, once the instrument was in Mode 7.2. Since this mode has been and will continue as the main mode of operation, the NRT product is only available for Mode 7.2.

Feb. 22, 2016 V1.2 _ Corresponds to V1_02 L2 Product Software

Data File Name: CATS_L2O-M7.1-V1-02_05kmNRT.2014-09-17T00-31-01UTC.hdf

Table 1: CATS-ISS 5 km Near Real-Time Record Summary for Mode 7.2

Record Name	Reference Table	Record Size (Bytes)	Records/ File	File Size (Bytes)
Metadata	Table 4	2,500	1	2,500
Geolocation and Viewing Geometry	Table 5	302	4,155	1,254,810
5 km Near Real-Time	Table 6	9672	4,155	40,187,160
Total Bytes/Granule (Mode 7.2)		**12,444**		**41,444,470**

Table 2: CATS-ISS Metadata Record (1 per granule)

Parameter	Data Type	Units	Nominal Range	Elem/ Granule	Bytes
Product ID	Char	N/A		1	40
Product_Version_Number	Char	N/A		1	40
Product_Creation_Date	Char	N/A		1	40
L1_Input_Version_Number	Char	N/A		1	40
Product_Creator	Char	N/A		1	40
Granule_Start_DateTime	Char	N/A		1	40
Granule_Stop_DateTime	Char	N/A		1	40
Granule_Production_DateTime	Char	N/A		1	40
Granule_Start_Latitude	Float	deg		1	4
Granule_Start_Longitude	Float	deg		1	4
Granule_Stop_Latitude	Float	deg		1	4
Granule_Stop_Longitude	Float	deg		1	4
Granule_Start_RDM	Float	N/A		1	4
Granule_Stop_RDM	Float	N/A		1	4
Number_5km_Profiles	Ulong	N/A		1	4
Horizontal_Resolution	Int	km		1	2
Number_Bins	Int	N/A		1	2
Bin_Size	Float	km		1	4
Percent_Profiles_Bad	Float	%		2	8
Bin_Altitude_Array	Float	km	-2, 30	534	2136
Total Bytes/Granule (All Modes)					**2500**

Table 3: CATS-ISS Profile Geolocation and Viewing Geometry Record

Parameter	Data Type	Units	Nominal Range	Elem/Rec	Bytes
CATS_Fore_FOV_Latitude	Float	deg	-60 - 60	3	12
CATS_Fore_FOV_Longitude	Float	deg	-180 - 180	3	12
CATS_Fore_FOV_Angle	Float	deg	-10 - 10	1	4
Index_Top_Bin	Int	N/A	0 - 533	1	2
Total Bytes/Sec Mode 7.2					**302**

Nominal Granule will span roughly 45 minutes (1/2 orbit) or 2700 seconds

Table 4: CATS-ISS 5 km Near Real-Time Record

Parameter	Data Type	Units	Nominal Range	Elem/ Rec	Bytes
Profile_UTC_Date	Long	UTC		1	8
Profile_UTC_Time	double	UTC		3	48
Profile_ID	ULong			1	8
Day_Night_Flag	Byte	N/A	0-2	1	2
Surface_Type_Fore_FOV	Byte	N/A		1	2
Lidar_Surface_Altitude_Fore_FOV	Float	km	0-6	1	4
DEM_Surface_Altitude_Fore_FOV	Float	km	0-6	1	4
Sky_Condition_Fore_FOV	Integer	N/A	0-3	1	2
Feature_Type_Fore_FOV	Integer	N/A	0-4	533	1066
Feature_Type_Score_Fore_FOV	Integer	N/A	-10-10	533	1066
Feature_Subtype_Fore_FOV	Integer	N/A	0-12	533	1066
Attenuated_Backscatter_1064_Fore_FOV	Float	$km^{-1}sr^{-1}$	0-1.8	533	2132
Attenuated_Backscatter_Uncertainty_1064_Fore_FOV	Float	%	0-1.0	533	2132
Volume_Depolarization_Ratio_1064_Fore_FOV	Float	N/A	0-1.0	533	2132
Total Bytes/Sec Mode 7.2					**9672**

Table 7: Definitions of CATS Vertical Feature Mask Parameters

Parameter	Interpretation
Sky_Condition	0 = clean skies (no clouds/aerosols) 1 = clear skies (no clouds) 2 = cloudy skies (no aerosols) 3 = hazy/cloudy (both clouds/aerosols)
Feature_Type	0 = invalid 1 = cloud 2 = undetermined 3 = aerosol 4 = no signal (attenuated)
Feature_Type_Score	| 10 | = high confidence | 1 | = low confidence 0 = zero confidence
Feature_SubType	0 = invalid 1 = water cloud 2 = unknown cloud phase 3 = ice cloud 4 = marine aerosol 5 = marine mixture aerosol 6 = dust 7 = dust mixture 8 = clean/background aerosol 9 = polluted continental aerosol 10 = smoke 11= volcanic aerosol

Appendix A: ISS Payload Broadcast Ancillary Data (Dataset 16)

These variables should be included in downlinked data stream.

Variable sequence number	Description
1	X-CTRS(Conventional Terrestrial Reference System) Position,- MSP(Most significant place)
2	X-CTRS Position - LSP(Least significant place)
3	Y-CTRS Position - MSP
4	Y-CTRS Position - LSP
5	Z-CTRS Position – MSP
6	Z-CTRS Position – LSP
7	X-CTRS Velocity – MSP
8	X-CTRS Velocity – LSP
9	Y-CTRS Velocity – MSP
10	Y-CTRS Velocity – LSP
11	Z-CTRS Velocity – MSP
12	Z-CTRS Velocity – LSP
13	Scalar Part of Local Vertical Local Horizontal (LVLH) Quaternion - MSP
14	Scalar Part of LVLH Quaternion – LSP
15	X-Component of Vector Part of Quaternion - MSP
16	X-Component of Vector Part of Quaternion - LSP
15	Y-Component of Vector Part of Quaternion - MSP
16	Y-Component of Vector Part of Quaternion - LSP
15	Z-Component of Vector Part of Quaternion - MSP
16	Z-Component of Vector Part of Quaternion – LSP
17-bits 8-9	Quality of Attitude Rate Data
17-bits 10-11	Quality of Solar LOS Data
17-bits 12-13	Quality of J2000 to Body Quaternion Data
18-bits 14-15	Status of Orbital Data
19	USGNC PC D Coarse Time Tag - MSP
20	USGNC PC D Coarse Time Tag - LSP