

Mars Reconnaissance Orbiter

Mars Climate Sounder Derived Data Record (DDR) Software Interface Specification

Version 1.2
October 25, 2012

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CHANGE LOG

DATE	SECTIONS CHANGED	REASON FOR CHANGE	REVISION
12/15/07	All	First draft	Draft v1.0
4/1/08	All	Revision	Draft v1.0
5/20/08	3.2, appendix	Update column names	Draft v1.0
6/05/08	2.2, 2.3.4, 2.4.2, 3.1, Appendix A,B	Update to match latest DDR products and fix <td> values	v1.1
10/25/12	2.1, 2.1.1, 2.3.1, 2.4.3, 3.2, Table 2, Table 3	Update to match latest DDR products and fix typos	v1.2

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ACRONYMS AND ABBREVIATIONS

ASCII	American Standard Code for Information Interchange
CODMAC	Committee on Data Management and Computation
DDR	Derived Data Record
EDR	Experiment Data Record
FOV	Field of View
GDS	Ground Data Systems
ICD	Interface Control Document
ISO	International Standards Organization
JPL	Jet Propulsion Laboratory
Kbyte	Kilobytes
LSB	Least Significant Byte
MB	Mega Bytes
MCS	Mars Climate Sounder
MRO	Mars Reconnaissance Orbiter
MSB	Most Significant Byte
NASA	National Aeronautics and Space Administration
OBA	Optics Bench Assembly
ODL	Object Description Language
PMIRR	Pressure Modulator Infrared Radiometer
PDS	Planetary Data System
RAM	Random Access Memory
RDR	Reduced Data Record
RSDS	Raw Science Data Server
SIS	Software Interface Specification
TBD	To Be Determined
TDS	Telemetry Delivery Subsystem
URL	Universal Resource Locator
UTC	Universal Time Coordinate

GLOSSARY

TERM	DEFINITION
Meta-Data	Selected or summary information about data. PDS catalog objects and data product labels are forms of meta-data for summarizing important aspects of data sets and data products.
Profile	The vertical distribution, as a function of atmospheric pressure, of some physical property, such as temperature or water vapor amount

1. INTRODUCTION

1.1 Purpose and Scope

The purpose of this data product Software Interface Specification (SIS) is to provide users of the Mars Climate Sounder (MCS) Derived Data Record (DDR) with a detailed description of the product and a description of how it was generated, including data sources and destinations. The document is intended to provide enough information to enable users to understand the MCS DDR data product. The users for whom this document is intended are software developers of the programs used in generating the DDR products and scientists who will analyze the data, including those associated with the Mars Reconnaissance Orbiter (MRO) Project and those in the general planetary science community.

1.2 Contents

This data product SIS describes how the MRO MCS instrument acquires its data, and how the data are processed, formatted, labeled, and uniquely identified. This document discusses standards used in generating the product and software that may be used to access the product. The data product structure and organization is described in sufficient detail to enable a user to read the product. Finally, an example of a product label is provided.

1.3 Applicable Documents and Constraints

This data product SIS is responsive to the following MRO documents:

1. Mars Exploration Program Data Management Plan, R. E. Arvidson, S. Slavney and S. Nelson, Rev. 3, March 20, 2002.
2. Mars Reconnaissance Orbiter Project Data Archive Generation, Validation and Transfer Plan, R. E. Arvidson, S. Noland and S. Slavney, JPL D-22246, July 27, 2005.

This SIS is also consistent with the following Planetary Data System documents:

3. Planetary Data System Archive Preparation Guide, Version .050503, JPL D-31224, May 3, 2005.
4. Planetary Data System Data Standards Reference, Version 3.6, JPL D-7669, Part 2, August 1, 2003.
5. Planetary Science Data Dictionary Document, JPL D-7116, August 28, 2002.
6. Mars Reconnaissance Orbiter Mars Climate Sounder (MCS) Science Team and PDS Atmospheres Node Interface Control Document (ICD), J. Murphy, April 30, 2004.

1.4 Relationships with Other Interfaces

The MCS Derived Data Record (DDR) products are derived from the MRO/MCS Reduced Data Product (RDR) data sets. And the completeness and quality of

the RDR data sets will affect the coverage and/or quality of the DDR products.

2. DATA PRODUCT CHARACTERISTICS AND ENVIRONMENT

2.1 Instrument Overview

The Mars Climate Sounder is a follow-on experiment to PMIRR, the Pressure Modulator Infrared Radiometer lost with the Mars Observer spacecraft, and to PMIRR2, lost with the Mars Climate Orbiter. MCS observes radiation with 21 detectors in each of nine spectral bands; eight thermal infrared channels are used to characterize atmospheric temperature, pressure, water vapor, and condensates, while the remaining spectral channel (operating in the visible and near infrared, 0.3-3.0 microns) is used primarily to understand the effects of solar radiation on the Martian energy budget.

MCS looks near the horizon of Mars at the atmospheric limb to observe the atmosphere in 21 vertically stacked samples simultaneously, with measurements centered approximately 5 kilometers (3 miles) apart at the limb. From these observations vertical distributions ("profiles") of temperature, pressure, water vapor, dust, and condensates are determined. These profiles can be combined into daily, three-dimensional global maps for both daytime and nighttime. Analyzing these profiles and derived maps should lead to a better understanding of Martian weather and, eventually, of Martian climate.

2.1.1 Hardware Overview

The Mars Climate Sounder is a nine channel infrared radiometer employing filter radiometry. These channels are distributed between two identical, boresighted telescopes, and an articulated elevation/azimuth mount allows the telescopes to view the surface of Mars, the limb of Mars, space, and calibration targets. The instantaneous field-of-view (FOV) response of each channel is defined by a linear, 21-element, thermopile detector array at the telescope focal plane, and its spectral response is defined by a focal plane bandpass filter.

The MCS structure consists of an instrument optics bench assembly (OBA), an elevation/azimuth yoke, and an instrument mount. The OBA contains all of the instrument optical subassemblies, and is suspended from the yoke (Figure 1). Elevation and azimuth motors mounted on the yoke drive instrument articulation. The OBA is temperature controlled, and internal temperature gradients are minimized by design. Radiometric calibration is provided by views of blackbody and solar targets mounted on the yoke. The electronics subassemblies control signal processing, instrument operation and articulation, command processing, and data processing and are distributed between the OBA and the yoke. Figure 1 shows the mechanical configuration of the instrument with the major components

indicated. Figure 2 gives a schematic representation of the optical layout.



Figure 1. Instrument Configuration

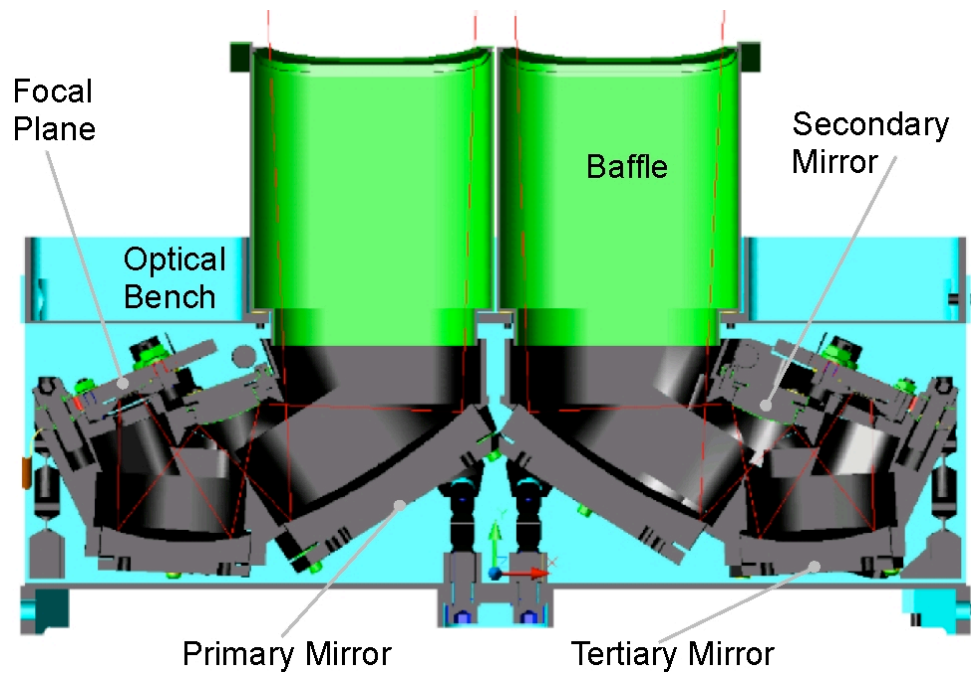


Figure 2. Optics Assembly (Telescopes A & B)

Telescope/ Channel #	Bandpass cm ⁻¹	Band Center - μ m	Measurement Function
A1	595 - 615	16.5	Temperature 20-40 km
A2	615 - 645	15.9	Temperature 40-80 km, Pressure
A3	635 - 665	15.4	Temperature 40-80 km, Pressure
A4	820 - 870	11.8	Dust and Condensate (D&C) extinction 0-80 km
A5	400 - 500	22.2	Temperature 0-20km, D&C extinction 0-80 km
A6	3300 - 33000	1.65	Polar Radiative Balance
B1	290 - 340	31.7	Temperature 0-20km, D&C extinction 0-80 km
B2	220 - 260	41.7	Water Vapor 0-40 km, D&C extinction 0-80 km
B3	230 - 245	42.1	Water Vapor 0-40 km, D&C extinction 0-80 km

Figure 3. MCS channel spectral characteristics

The detector arrays for channels A1 through A6 are located in the focal plane of telescope A. The detector arrays for channels B1 through B3 are located in the focal plane of telescope B.

Each MCS spectral channel (Figure 3) has 21 FOVs defined by the individual detectors of the corresponding linear array. Nominal detector FOV dimensions, linear array length and linear array spacing in both focal planes are specified in Figure 4.

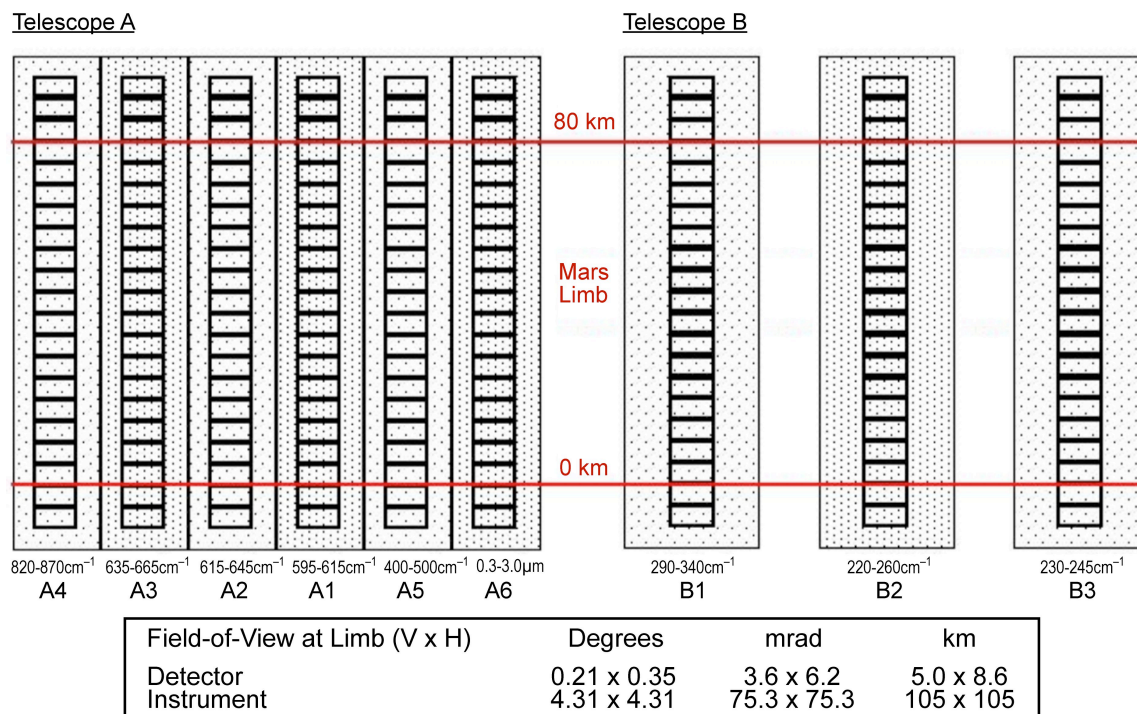


Figure 4. Detector and Filter Layout

2.2 Data Product Overview

The MCS software collects 192 sixteen-bit science measurements from the focal plane interface electronics every 2.048 seconds, along with associated instrument engineering and housekeeping measurements. The science and housekeeping data are organized into data packets that are transmitted to the spacecraft at the same 2.048-second spacing. The data packets are downlinked to the MRO Ground Data System (GDS) and placed into the Raw Science Data Server (RSDS). MCS software queries the data from the RSDS and assembles them into RDR data tables, each covering a 4 hour time period. Over the course of the mission, Derived Data Records (DDR) in the form of NASA Level 2 data products (retrieved geophysical profiles) are generated from the RDRs.

The DDR data will consist of profiles of successfully retrieved geophysical parameters, estimated retrieval and observation errors, and the geometry information to properly locate the profiles in space and time.

Each MCS DDR data product will consist of four files:

1. An ASCII formatted detached PDS label.
2. A detached PDS format file that describes the associated DDR metadata using a PDS Table object.
3. A detached PDS format file that describes the DDR data product using a PDS Container object.
4. An ASCII tabular data file containing the retrieved profiles.

These are described in Appendix A. Each MCS DDR table will cover 4 hours and be approximately 4 MB in size, but may be significantly smaller depending on the number of successful retrievals.

2.3 Data Processing

2.3.1 Data Processing Level

This document uses the Committee on Data Management and Computation (CODMAC) data level numbering system to describe the processing level of the DDR data product. MCS DDR data products are considered CODMAC “Level 5”, equivalent to NASA level 2. The DDR data files are generated from CODMAC Level 4 or “Resampled Data”, which are the time-ordered instrument science data. Refer to Table 1 for a definition of the CODMAC and NASA data processing levels.

Table 1: Processing Levels for Science Data Sets

NASA	CODMAC	Description
Packet data	Raw – Level 1	Telemetry data stream as received at the ground station, with science and engineering data embedded.
Level-0	Edited – Level 2	Instrument science data (e.g., raw voltages, counts) at full resolution, time ordered, with duplicates and transmission errors removed.
Level 1A	Calibrated - Level 3	Level 0 data that have been located in space and may have been transformed (e.g., calibrated, rearranged) in a reversible manner and packaged with needed ancillary and auxiliary data (e.g., radiances with the calibration equations applied).
Level 1B	Resampled - Level 4	Irreversibly transformed (e.g., resampled, remapped, calibrated) values of the instrument measurements (e.g., radiances, magnetic field strength).
Level 2	Derived - Level 5	Geophysical parameters, generally derived from Level 1 data, and located in space and time commensurate with instrument location, pointing, and sampling.
Level 3	Derived - Level 5	Geophysical parameters mapped onto uniform space-time grids.

2.3.2 Data Product Generation

The MCS DDR data products will be generated by the MCS Instrument Team at JPL. Due to the atmospheric structure resulting in radiance profiles with insufficient information as well as limitations in the retrieval (inversion) algorithm, profiles do not exist for some of the limb observations in the RDR data set.

2.3.3 Data Flow

MCS science and engineering telemetry are transferred to the MRO Project RSDS. Once transferred, the MCS software automatically processes the telemetry into Level 0 EDR data products. MCS software generates the Level 1B products from the Level 0 data. The MCS DDR data products are generated from the Level 1B data and then archived locally at the MCS operation center.

After an initial data validation period, the MCS team will assemble the data products and ancillary files into archive volumes and will transfer the assembled volume to the Atmospheres Node. The MCS DDR archive will be made available via data releases scheduled at three-month intervals as specified in the Mars Reconnaissance Orbiter Project Data Archive Generation, Validation and Transfer Plan (see Applicable document #2).

2.3.4 Labeling and Identification

The data set ID provided by the PDS for the MCS DDR data product is: MRO-M-MCS-5-DDR-V1.0. The version number is incremented should the entire DDR data set be revised. The data set name is "MRO MARS CLIMATE SOUNDER LEVEL 5 DDR V1.0".

The naming convention for the tables and detached labels follow the time-organization of the data and use the following naming convention (e.g. "2007070800_DDR.TAB):

yyyymmddhh_DDR.TAB; where:

- yyyy = year in which the data was acquired
- mm = month of the year in which the data was acquired
- dd = day of the month in which the data was acquired
- hh = hour of the day in which the data was acquired

Each MCS DDR data product has a detached PDS label in a separate file of the same name, extension .LBL: e.g. "2007070800_DDR.LBL". The PDS format files for each DDR data product will be MCS_DDR1.FMT for the metadata and MCS_DDR2.FMT for the profiles.

2.4 Standards Used in Generating Data Products

2.4.1 PDS Standards

The MCS DDR complies with Planetary Data System standards for file formats and directory names, PDS labels, as specified in the PDS Standards Reference [5] and the Planetary Science Data Dictionary Document [6].

2.4.2 Time Standards

The PDS label for an MCS DDR uses keywords denoting time values, such as start time, stop time, start spacecraft clock count, and stop spacecraft clock count. Each time value standard is defined according to the PDS keyword definition. See Appendix A.

In the data product label, Start Time and Stop Time values are stored in PDS compliant UTC date format, in the pattern YYYY-MM-DDTHH:MM:SS.SSS (four digit year, two digits for month, day, hour, minute and second, and three digits for decimal fractional second). Spacecraft clock start and stop count time values are stored in decimal seconds from the epoch 1980.

2.4.3 Coordinate Systems

All positions and vectors in the MCS DDR product files are specified in Areocentric spherical coordinates. All coordinates follow the MRO mission convention and use north latitude and east longitude.

2.4.4 Data Storage Conventions

The MCS DDR data files are stored as fixed-length ASCII tables. The detached PDS labels for MCS DDR's are stored as ASCII text, as are the format files. Each record is terminated with a carriage return followed by a line feed.

2.5 Data Validation

MCS DDR products will be validated before being released to the PDS. Validation is accomplished in two parts: validation for scientific integrity and validation for compliance with PDS standards. MCS Team members are expected to conduct validation for scientific integrity in the course of their analysis of the products. Science validation is meant to ensure that data products contain the expected measurements and that they are otherwise suitable for analysis. The details of the science validation process are the responsibility of the MCS Team.

Validation for PDS compliance will be performed by the PDS Atmospheres Node and is meant to ensure that data products conform to PDS standards and to the

specifications in this SIS.

A data set must also pass a peer review before it is accepted by PDS. The MCS Team and the PDS Atmospheres Node will convene a peer review committee made up of scientists and data engineers. The committee will examine the data set to make sure it is complete and meets the product specifications as defined in the SIS. The committee will include a PDS representative to ensure that the data set is in compliance with PDS standards.

3. DETAILED DATA PRODUCT SPECIFICATIONS

3.1 Data Product Structure and Organization

The DDR data products will be located in the DATA directory of the DDR volume. The files will be grouped into directories with one directory per day. Each directory name will be in the format YYYYMMDD. Within each directory there will be up to 6 data product files and the corresponding labels. The labels will point to the corresponding data files, and contain pointers to format labels detailing the column layout of the data files. The data product file names will be in the format YYYYMMDDHH_DDR.TAB for the data tables, and YYYYMMDDHH_DDR.LBL for the labels.

The individual profiles are stored in time order in the data file. Each profile contains 106 records (or rows). The first record/row (in the format described by MCS_DDR1.FMT) contains information that pertains to the entire profile. This includes timestamps, geometry, surface and column geophysical quantities, quality flags and pointers to the source RDR records. This is referred to as the profile "meta-data" record. The next 105 records/rows (each in the format described by MCS_DDR2.FMT) are the 105 pressure surfaces and contain the (geophysical and geographic) profile quantities. The second profile in the data file then follows, starting with its meta-data record and block of 105 level records. This continues throughout the file with one meta-data record and 105 layer records for each profile.

3.2 Data Format Descriptions

The MCS DDR data product file is a fixed record-length ASCII table. Descriptions of the data contained within the table columns are provided below:

Table 2: MRO MCS Measurement Data Components

Column #	Name	Data Type	Length	Description
1	1	ASCII_INTEGER	1	A quality indicator: 0 means this record contains valid data
2	DATE	CHARACTER	14	Date of profile (UTC)

3	UTC	CHARACTER	15	Time of profile (UTC)
4	SCLK	ASCII_REAL	15	The MRO Spacecraft Clock of profile, without partition, including decimal thousandths of a second.
5	L_S	ASCII_REAL	10	Solar Longitude of Mars (deg).
6	SOLAR_DIST	ASCII_REAL	14	Distance from the center of Mars to the center of the Sun (km).
7	ORB_NUM	ASCII_INTEGER	8	MRO Orbit Number.
8	GQUAL	ASCII_INTEGER	6	Geometry quality: 0 = good. 3 = undetermined attitude information 4 = Pointing is incorrect and geometry is not fixed 5 = Pointing may be incorrect and geometry is not fixed 6 = Pointing is incorrect and geometry was fixed
9	SOLAR_LAT	ASCII_REAL	10	The Mars-centric north latitude of the Sun, in degrees
10	SOLAR_LON	ASCII_REAL	11	The Mars-centric east longitude of the Sun, in degrees
11	SOLAR_ZEN	ASCII_REAL	11	The angular separation, in degrees, between the vector from the center of Mars to the scene point (see below) and the vector from the center of Mars to the Sun
12	LTST	ASCII_REAL	9	Mars Local True Solar Time of the profile in fraction of sol.
13	PROFILE_LAT	ASCII_REAL	10	Latitude of the center of the profile (deg), see the next section for the latitude of specific pressures.
14	PROFILE_LON	ASCII_REAL	11	Longitude of the center of the profile (deg), see the next section for the longitude of specific pressures.
15	PROFILE_RAD	ASCII_REAL	10	The distance, in kilometers, from the center of Mars to the center of the profile.
16	PROFILE_ALT	ASCII_REAL	10	The distance, in kilometers, from the center of the profile to the local MOLA elevation.
17	LIMB_ANG	ASCII_REAL	11	The angle, in degrees, between the local vertical and the MCS arrays during the observations for the profile.
18	ARE_RAD	ASCII_REAL	9	MOLA aeroid radius at the center point of the profile (km)
19	SURF_LAT	ASCII_REAL	10	Latitude of the surface point for the profile, or if there is no surface sounding (see column 46, SURF_QUAL) the latitude of the tangent point for the lowest line-of-sight that does not intersect the surface (deg).
20	SURF_LON	ASCII_REAL	11	Longitude of the surface point for the profile, or if there is no surface sounding (see column 46, SURF_QUAL) the longitude of the tangent point for the lowest line-of-sight that does not intersect the surface (deg).
21	SURF_RAD	ASCII_REAL	10	The distance, in kilometers, from the center of Mars to the surface point. If there is no surface sounding (see column 46, SURF_QUAL), this is the distance from the center of Mars to the tangent point for the lowest line-of-sight that does not intersect the surface. In either case, this is also the radius of the altitude grid for the profile.
22	T_SURF	ASCII_REAL	9	Surface temperature (K).
23	T_SURF_ERR	ASCII_REAL	11	Surface temperature uncertainty (K).
24	T_NEAR_SURF	ASCII_REAL	12	Near surface atmospheric temperature (K).

25	T_NEAR_SURF_ERR	ASCII_REAL	16	Near surface atmospheric temperature uncertainty (K).
26	DUST_COLUMN	ASCII_REAL	12	Dust column opacity at 463 wavenumbers (or 21.6 microns).
27	DUST_COLUMN_ERR	ASCII_REAL	16	Dust column opacity uncertainty at 463 wavenumbers (or 21.6 microns).
28	H2OVAP_COLUMN	ASCII_REAL	15	Water vapor column amount (precipitable-microns, pr-micron).
29	H2OVAP_COLUMN_ERR	ASCII_REAL	19	Water vapor column amount uncertainty precipitable-microns, pr-micron).
30	H2OICE_COLUMN	ASCII_REAL	15	Water ice column opacity at 843 wavenumbers (or 11.9 microns).
31	H2OICE_COLUMN_ERR	ASCII_REAL	19	Water ice column opacity uncertainty at 843 wavenumbers (or 11.9 microns).
32	CO2ICE_COLUMN	ASCII_REAL	15	CO2 ice column opacity at 607 wavenumbers (or 16.5 microns).
33	CO2ICE_COLUMN_ERR	ASCII_REAL	19	CO2 ice column opacity uncertainty at 607 wavenumbers (or 16.5 microns).
34	P_SURF	ASCII_REAL	9	Surface pressure (Pa); 100 Pa = 1 mBar
35	P_SURF_ERR	CHARACTER	13	Surface pressure uncertainty (Pa); 100 Pa = 1 mBar
36	P_RET_ALT	ASCII_REAL	10	Altitude above the 'surface' (column 21) at which pressure is retrieved (km).
37	P_RET	ASCII_REAL	11	Retrieved pressure (Pa)
38	P_RET_ERR	ASCII_REAL	10	Retrieved pressure uncertainty (Pa)
39	RQUAL	ASCII_INTEGER	6	Radiance Quality Flag
40	PQUAL	ASCII_INTEGER	7	Pressure retrieval quality flag. 0 = good.
41	TQUAL	ASCII_INTEGER	7	Temperature retrieval quality flag. 0 = successful limb and nadir retrieval (coverage to the surface). 1 = successful limb and surface retrieval (no near surface atmosphere). 2 = successful limb retrieval (no surface or near surface atmosphere). 3 = truncated limb retrieval (profile stops well above the surface).
42	DUST_QUAL	ASCII_INTEGER	10	Dust retrieval quality flag. 2 = successful limb retrieval (full dust profile). 3 = truncated limb retrieval (profile stops well above the surface). 9 = dust not retrieved.
43	H2OVAP_QUAL	ASCII_INTEGER	13	Water vapor retrieval quality flag. 9 = not retrieved.
44	H2OICE_QUAL	ASCII_INTEGER	13	Vertical extent of the water ice retrieval. 2 = successful limb retrieval (full water ice profile). 3 = truncated limb retrieval (profile stops well above the surface)." 9 = water ice not retrieved.
45	CO2ICE_QUAL	ASCII_INTEGER	13	CO2 ice retrieval quality flag. 9 = not retrieved.
46	SURF_QUAL	ASCII_INTEGER	10	Surface/near surface retrieval quality flag. [need list of values] ?
47	OBS_QUAL	ASCII_INTEGER	10	Quality and viewing direction of the observations used for the retrieval. 0 = Standard observations, forward in-track viewing (Azimuth = 180 deg). 1 = Limb staring observations (reduced calibration quality), forward in-track viewing (Azimuth = 180

				deg)." 2 = Standard observations, right forward off-track viewing (180 deg < Azimuth < 270 deg). 3 = Standard observations, right cross-track viewing (Azimuth = 270 deg). 4 = Standard observations, left forward off-track viewing (90 deg < Azimuth < 180 deg). 5 = Standard observations, left cross-track viewing (Azimuth = 90 deg). 6 = Standard observations, left aft off-track viewing (0 deg < Azimuth < 90 deg). 7 = Standard observations, aft in-track viewing (Azimuth = 0 deg).
48	REF_SCLK_0	ASCII_REAL	14	The MRO Spacecraft Clock, without partition, including decimal thousandths of a second; record n [0 to 9] from RDR used in the retrieval.
49	REF_SCLK_1	ASCII_REAL	14	The MRO Spacecraft Clock, without partition, including decimal thousandths of a second; record n [0 to 9] from RDR used in the retrieval.
50	REF_SCLK_2	ASCII_REAL	14	The MRO Spacecraft Clock, without partition, including decimal thousandths of a second; record n [0 to 9] from RDR used in the retrieval.
51	REF_SCLK_3	ASCII_REAL	14	The MRO Spacecraft Clock, without partition, including decimal thousandths of a second; record n [0 to 9] from RDR used in the retrieval.
52	REF_SCLK_4	ASCII_REAL	14	The MRO Spacecraft Clock, without partition, including decimal thousandths of a second; record n [0 to 9] from RDR used in the retrieval.
53	REF_SCLK_5	ASCII_REAL	14	The MRO Spacecraft Clock, without partition, including decimal thousandths of a second; record n [0 to 9] from RDR used in the retrieval.
54	REF_SCLK_6	ASCII_REAL	14	The MRO Spacecraft Clock, without partition, including decimal thousandths of a second; record n [0 to 9] from RDR used in the retrieval.
55	REF_SCLK_7	ASCII_REAL	14	The MRO Spacecraft Clock, without partition, including decimal thousandths of a second; record n [0 to 9] from RDR used in the retrieval.
56	REF_SCLK_8	ASCII_REAL	14	The MRO Spacecraft Clock, without partition, including decimal thousandths of a second; record n [0 to 9] from RDR used in the retrieval.
57	REF_SCLK_9	ASCII_REAL	14	The MRO Spacecraft Clock, without partition, including decimal thousandths of a second; record n [0 to 9] from RDR used in the retrieval.
58	REF_DATE_0	CHARACTER	14	Date of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.
59	REF_UTC_0	CHARACTER	15	Time of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.
60	REF_DATE_1	CHARACTER	14	Date of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.
61	REF_UTC_1	CHARACTER	15	Time of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.
62	REF_DATE_2	CHARACTER	14	Date of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.
63	REF_UTC_2	CHARACTER	15	Time of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.
64	REF_DATE_3	CHARACTER	14	Date of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.
65	REF_UTC_3	CHARACTER	15	Time of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.

66	REF_DATE_4	CHARACTER	14	Date of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.
67	REF_UTC_4	CHARACTER	15	Time of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.
68	REF_DATE_5	CHARACTER	14	Date of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.
69	REF_UTC_5	CHARACTER	15	Time of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.
70	REF_DATE_6	CHARACTER	14	Date of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.
71	REF_UTC_6	CHARACTER	15	Time of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.
72	REF_DATE_7	CHARACTER	14	Date of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.
73	REF_UTC_7	CHARACTER	15	Time of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.
74	REF_DATE_8	CHARACTER	14	Date of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.
75	REF_UTC_8	CHARACTER	15	Time of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.
76	REF_DATE_9	CHARACTER	14	Date of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.
77	REF_UTC_9	CHARACTER	15	Time of measurement (UTC); record n [0 to 9] from RDR used in the retrieval.

Table 3: MRO MCS Measurement Metadata Components

Column #	Name	Data Type	Length	Description
1	1	ASCII_INTEGER	1	A quality indicator: 0 means this record contains valid data.
2	PRES	ASCII_REAL	13	Pressure surface for this layer of the profile (Pa). The pressures were calculated from $p(i) = p_0 \cdot \exp(-.125 \cdot (i-10))$, $i = 1..105$ where $p_0 = 610$.
3	T	ASCII_REAL	8	Temperature on the pressure surface (K).
4	T_ERR	ASCII_REAL	8	Temperature uncertainty on the pressure surface (K).
5	DUST	ASCII_REAL	11	Dust opacity per km on the pressure surface at 463 wavenumbers (or 21.6 microns).
6	DUST_ERR	ASCII_REAL	11	Dust opacity uncertainty on the pressure surface (opacity per km at 463 wavenumbers or 21.6 microns).
7	H2OVAP	ASCII_REAL	11	Water vapor volume mixing ratio on the pressure surface.
8	H2OVAP_ERR	ASCII_REAL	11	Water vapor uncertainty on the pressure surface (volume mixing ratio, ppm).
9	H2OICE	ASCII_REAL	11	Water ice opacity per km on the pressure surface at 843 wavenumbers (or 11.9 microns).
10	H2OICE_ERR	ASCII_REAL	11	Water ice opacity uncertainty on the pressure surface (opacity per km in at 843 wavenumbers or 11.9 microns).
11	CO2ICE	ASCII_REAL	11	CO2 ice opacity per km on the pressure surface at 607 wavenumbers (or 16.5 microns).
12	CO2ICE_ERR	ASCII_REAL	11	CO2 ice opacity uncertainty on the pressure

				surface (opacity per km at 607 wavenumbers or 16.5 microns).
13	ALT	ASCII_REAL	8	Altitude of the pressure surface above the surface point (DDR1, column 21) (km).
14	LAT	ASCII_REAL	10	Latitude of the center of the measurement region on the pressure surface (deg).
15	LON	ASCII_REAL	10	Longitude of the center of the measurement region on the pressure surface (deg).

3.3 Label and Header Descriptions

Each MCS DDR data product is described by a detached PDS label in a separate file with the same name, extension “.LBL”. A label file is stored in the same directory as the data file it describes.

A PDS label is object-oriented and describes the objects in the data file. The PDS label contains keywords for product identification and for data object definitions. The label also contains descriptive information needed to interpret or process the data objects in the file.

PDS labels are written in Object Description Language (ODL) [7]. PDS label statements have the form of "keyword = value". Each label statement is terminated with a carriage return character (ASCII 13) and a line feed character (ASCII 10) sequence to allow the label to be read by many operating systems. Pointer statements with the following format are used to indicate the location of data objects in the file:

^TABLE = filename,location

where the caret character (^, also called a pointer) is followed by the name of the specific data object. The ‘location’ is the starting record number (counting from one) for the data within the file, e.g.

^TABLE = ("2005091216_DDR.TAB", 5)

The data files themselves will usually contain rows of embedded headers, marked by the ‘#’ symbols, which are used for file comments.

The PDS label will also include “pointers” to two other files that define the table column definitions, in order to avoid repeating the lengthy definitions in every label. The column definition files have the extension “.FMT” and are stored in the LABEL directory of the DDR archive.

An example of MCS DDR label is in Appendix A; an example of the two format files is in Appendix B

4. APPLICABLE SOFTWARE

4.1 Utility Programs

Because the MCS DDR products are formatted as columnar ASCII data, they can be read and manipulated by standard, public-domain software. For this reason, no special utilities are provided.

4.2 Applicable PDS Software Tools

PDS-labeled tables can be viewed with the program NASAView, developed by the PDS and available for a variety of computer platforms from the PDS web site http://pds.nasa.gov/tools/software_download.cfm. There is no charge for NASAView.

4.3 Software Distribution and Update Procedures

None at this time.

APPENDIX A - EXAMPLE OF AN MCS DDR LABEL

```

PDS_VERSION_ID          = PDS3

RECORD_TYPE              = STREAM
RECORD_BYTES             = 17954
FILE_RECORDS             = 171
DESCRIPTION               = "This table contains Level 2 geophysical profile
                             data records from the Mars Climate Sounder collected
                             during the orbital operations phase of the Mars
                             Reconnaissance Orbiter mission."

^TABLE                   = ("2006093000_DDR.TAB", 2855<BYTES>)
DATA_SET_ID              = "MRO-M-MCS-5-DDR-V1.0"
MISSION_NAME              = "MARS RECONNAISSANCE ORBITER"
INSTRUMENT_HOST_NAME     = "MARS RECONNAISSANCE ORBITER"
INSTRUMENT_NAME           = "MARS CLIMATE SOUNDER"
PRODUCT_NAME              = "MCS DDR"
PRODUCT_ID                = "2006093000_DDR.TAB"
TARGET_NAME               = "MARS"
START_TIME                = 2006-09-30T00:00:11.327
STOP_TIME                 = 2006-09-30T03:52:23.795
SPACECRAFT_CLOCK_START_COUNT = 844041630.035
SPACECRAFT_CLOCK_STOP_COUNT = 844055562.155
PRODUCT_CREATION_TIME     = 2008-05-22T14:23:14
START_ORBIT_NUMBER        = 828
STOP_ORBIT_NUMBER         = 830
START_SOLAR_LONGITUDE     = 113.71489
STOP_SOLAR_LONGITUDE      = 113.78916

OBJECT                   = TABLE
  INTERCHANGE_FORMAT      = ASCII
  ROW_BYTES               = 17954
  ROWS                    = 171
  COLUMNS                 = 1652
  ^STRUCTURE              = "MCS_DDR1.FMT"

OBJECT                   = CONTAINER
  NAME                    = FRAME_STRUCTURE
  START_BYTE               = 1050
  BYTES                    = 161
  REPETITIONS              = 105
  ^STRUCTURE               = "MCS_DDR2.FMT"
  DESCRIPTION              = "See MCS_DDR1.FMT & MCS_DDR2.FMT"
  END_OBJECT              = CONTAINER
END_OBJECT               = TABLE

END

```

APPENDIX B - EXAMPLE OF MCS DDR FORMAT FILES

B.1 Example Metadata Format File

```

OBJECT          = COLUMN
  COLUMN_NUMBER = 1
  NAME          = 1
  DATA_TYPE    = ASCII_INTEGER
  START_BYTE    = 1
  BYTES         = 1
  DESCRIPTION    = "A quality indicator: 0 means this record contains valid data"
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 2
  NAME          = DATE
  DATA_TYPE    = CHARACTER
  START_BYTE    = 3
  BYTES         = 14
  DESCRIPTION    = "Date of profile (UTC)"
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 3
  NAME          = UTC
  DATA_TYPE    = CHARACTER
  START_BYTE    = 18
  BYTES         = 15
  DESCRIPTION    = "Time of profile (UTC)"
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 4
  NAME          = SCLK
  DATA_TYPE    = ASCII_REAL
  START_BYTE    = 34
  BYTES         = 15
  DESCRIPTION    = "The MRO Spacecraft Clock of profile, without
partition, including decimal thousandths of a second."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 5
  NAME          = L_S
  DATA_TYPE    = ASCII_REAL
  START_BYTE    = 50
  BYTES         = 10
  DESCRIPTION    = "Solar Longitude of Mars (deg)."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 6
  NAME          = SOLAR_DIST
  DATA_TYPE    = ASCII_REAL
  START_BYTE    = 61
  BYTES         = 14
  DESCRIPTION    = "Distance from the center of Mars to the center
of the Sun (km)."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 7
  NAME          = ORB_NUM
  DATA_TYPE    = ASCII_INTEGER
  START_BYTE    = 76
  BYTES         = 8
  DESCRIPTION    = "MRO Orbit Number."
END_OBJECT      = COLUMN

```

```

OBJECT          = COLUMN
  COLUMN_NUMBER = 8
  NAME          = GQUAL
  DATA_TYPE    = ASCII_INTEGER
  START_BYTE    = 85
  BYTES         = 6
  DESCRIPTION   = "Geometry quality:
    0 = good.
    3 = undetermined attitude information
    4 = Pointing is incorrect and geometry is not fixed
    5 = Pointing may be incorrect and geometry is not fixed
    6 = Pointing is incorrect and geometry was fixed"
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 9
  NAME          = SOLAR_LAT
  DATA_TYPE    = ASCII_REAL
  START_BYTE    = 92
  BYTES         = 10
  DESCRIPTION   = "The Mars-centric north latitude of the Sun, in degrees"
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 10
  NAME          = SOLAR_LON
  DATA_TYPE    = ASCII_REAL
  START_BYTE    = 103
  BYTES         = 11
  DESCRIPTION   = "The Mars-centric east longitude of the Sun, in degrees"
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 11
  NAME          = SOLAR_ZEN
  DATA_TYPE    = ASCII_REAL
  START_BYTE    = 115
  BYTES         = 11
  DESCRIPTION   = "The angular separation, in degrees, between the vector from
    the center of Mars to the scene point (see below) and the vector from the center
    of Mars to the Sun"
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 12
  NAME          = LTST
  DATA_TYPE    = ASCII_REAL
  START_BYTE    = 127
  BYTES         = 9
  DESCRIPTION   = "Mars Local True Solar Time of the profile in fraction of sol."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 13
  NAME          = PROFILE_LAT
  DATA_TYPE    = ASCII_REAL
  START_BYTE    = 137
  BYTES         = 12
  DESCRIPTION   = "Latitude of the center of the profile (deg), see the next section
    for the latitude of specific pressures."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 14
  NAME          = PROFILE_LON
  DATA_TYPE    = ASCII_REAL
  START_BYTE    = 150
  BYTES         = 12
  DESCRIPTION   = "Longitude of the center of the profile (deg), see the next
    section
    for the longitude of specific pressures."
END_OBJECT      = COLUMN

```

```

OBJECT          = COLUMN
  COLUMN_NUMBER = 15
  NAME          = PROFILE_RAD
  DATA_TYPE    = ASCII_REAL
  START_BYTE    = 163
  BYTES         = 12
  DESCRIPTION    = "The distance, in kilometers, from the center of Mars to the
center
  of the profile."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 16
  NAME          = PROFILE_ALT
  DATA_TYPE    = ASCII_REAL
  START_BYTE    = 176
  BYTES         = 12
  DESCRIPTION    = "The distance, in kilometers, from the center of the profile to
the
  local MOLA elevation."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 17
  NAME          = LIMB_ANG
  DATA_TYPE    = ASCII_REAL
  START_BYTE    = 189
  BYTES         = 11
  DESCRIPTION    = "The angle, in degrees, between the local vertical and the MCS
arrays
  during the observations for the profile."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 18
  NAME          = ARE_RAD
  DATA_TYPE    = ASCII_REAL
  START_BYTE    = 201
  BYTES         = 9
  DESCRIPTION    = "MOLA asteroid radius at the center point of the profile (km)"
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 19
  NAME          = SURF_LAT
  DATA_TYPE    = ASCII_REAL
  START_BYTE    = 211
  BYTES         = 10
  DESCRIPTION    = "Latitude of the surface point for the profile, or if there is no
surface sounding (see column 46, SURF_QUAL) the latitude of the tangent point for the
lowest line-of-sight that does not intersect the surface (deg)."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 20
  NAME          = SURF_LON
  DATA_TYPE    = ASCII_REAL
  START_BYTE    = 222
  BYTES         = 11
  DESCRIPTION    = "Longitude of the surface point for the profile, or if there is no
surface sounding (see column 46, SURF_QUAL) the longitude of the tangent point for
the
lowest line-of-sight that does not intersect the surface (deg)."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 21
  NAME          = SURF_RAD
  DATA_TYPE    = ASCII_REAL
  START_BYTE    = 234
  BYTES         = 10
  DESCRIPTION    = "The distance, in kilometers, from the center of Mars to the

```

surface point. If there is no surface sounding (see column 46, SURF_QUAL), this is the distance from the center of Mars to the tangent point for the lowest line-of-sight that does not intersect the surface. In either case, this is also the radius of the altitude grid for the profile."

END_OBJECT = COLUMN

OBJECT = COLUMN
 COLUMN_NUMBER = 22
 NAME = T_SURF
 DATA_TYPE = ASCII_REAL
 START_BYTE = 245
 BYTES = 9
 DESCRIPTION = "Surface temperature (K)."
 END_OBJECT = COLUMN

OBJECT = COLUMN
 COLUMN_NUMBER = 23
 NAME = T_SURF_ERR
 DATA_TYPE = ASCII_REAL
 START_BYTE = 255
 BYTES = 11
 DESCRIPTION = "Surface temperature uncertainty (K)."
 END_OBJECT = COLUMN

OBJECT = COLUMN
 COLUMN_NUMBER = 24
 NAME = T_NEAR_SURF
 DATA_TYPE = ASCII_REAL
 START_BYTE = 267
 BYTES = 12
 DESCRIPTION = "Near surface atmospheric temperature (K)."
 END_OBJECT = COLUMN

OBJECT = COLUMN
 COLUMN_NUMBER = 25
 NAME = T_NEAR_SURF_ERR
 DATA_TYPE = ASCII_REAL
 START_BYTE = 280
 BYTES = 16
 DESCRIPTION = "Near surface atmospheric temperature uncertainty (K)."
 END_OBJECT = COLUMN

OBJECT = COLUMN
 COLUMN_NUMBER = 26
 NAME = DUST_COLUMN
 DATA_TYPE = ASCII_REAL
 START_BYTE = 297
 BYTES = 12
 DESCRIPTION = "Dust column opacity at 463 wavenumbers (or 21.6 microns)."
 END_OBJECT = COLUMN

OBJECT = COLUMN
 COLUMN_NUMBER = 27
 NAME = DUST_COLUMN_ERR
 DATA_TYPE = ASCII_REAL
 START_BYTE = 310
 BYTES = 16
 DESCRIPTION = "Dust column opacity uncertainty at 463 wavenumbers
 (or 21.6 microns)."
 END_OBJECT = COLUMN

OBJECT = COLUMN
 COLUMN_NUMBER = 28
 NAME = H2OVAP_COLUMN
 DATA_TYPE = ASCII_REAL
 START_BYTE = 327
 BYTES = 15
 DESCRIPTION = "Water vapor column amount (precipitable-microns, pr-micron)."
 END_OBJECT = COLUMN

OBJECT = COLUMN
 COLUMN_NUMBER = 29
 NAME = H2OVAP_COLUMN_ERR

```

DATA_TYPE          = ASCII_REAL
START_BYTE         = 343
BYTES              = 19
DESCRIPTION        = "Water vapor column amount uncertainty precipitable-microns,
pr-micron)."
END_OBJECT         = COLUMN

OBJECT              = COLUMN
COLUMN_NUMBER      = 30
NAME               = H2OICE_COLUMN
DATA_TYPE          = ASCII_REAL
START_BYTE         = 363
BYTES              = 15
DESCRIPTION        = "Water ice column opacity at 843 wavenumbers (or 11.9 microns)."
END_OBJECT         = COLUMN

OBJECT              = COLUMN
COLUMN_NUMBER      = 31
NAME               = H2OICE_COLUMN_ERR
DATA_TYPE          = ASCII_REAL
START_BYTE         = 379
BYTES              = 19
DESCRIPTION        = "Water ice column opacity uncertainty at 843 wavenumbers
(or 11.9 microns)."
END_OBJECT         = COLUMN

OBJECT              = COLUMN
COLUMN_NUMBER      = 32
NAME               = CO2ICE_COLUMN
DATA_TYPE          = ASCII_REAL
START_BYTE         = 399
BYTES              = 15
DESCRIPTION        = "CO2 ice column opacity at xxx wavenumbers (or yyy microns)."
END_OBJECT         = COLUMN

OBJECT              = COLUMN
COLUMN_NUMBER      = 33
NAME               = CO2ICE_COLUMN_ERR
DATA_TYPE          = ASCII_REAL
START_BYTE         = 415
BYTES              = 19
DESCRIPTION        = "CO2 ice column opacity uncertainty at xxx wavenumbers
(or yyy microns)."
END_OBJECT         = COLUMN

OBJECT              = COLUMN
COLUMN_NUMBER      = 34
NAME               = P_SURF
DATA_TYPE          = ASCII_REAL
START_BYTE         = 435
BYTES              = 9
DESCRIPTION        = "Surface pressure (Pa); 100 Pa = 1 mBar"
END_OBJECT         = COLUMN

OBJECT              = COLUMN
COLUMN_NUMBER      = 35
NAME               = P_SURF_ERR
DATA_TYPE          = CHARACTER
START_BYTE         = 445
BYTES              = 13
DESCRIPTION        = "Surface pressure uncertainty (Pa); 100 Pa = 1 mBar"
END_OBJECT         = COLUMN

OBJECT              = COLUMN
COLUMN_NUMBER      = 36
NAME               = P_RET_ALT
DATA_TYPE          = ASCII_REAL
START_BYTE         = 459
BYTES              = 10
DESCRIPTION        = "Altitude above the 'surface' (column 21) at which pressure is
retrieved (km)."
END_OBJECT         = COLUMN

```



```

OBJECT                = COLUMN
  COLUMN_NUMBER       = 37
  NAME                = P_RET
  DATA_TYPE          = ASCII_REAL
  START_BYTE          = 470
  BYTES               = 11
  DESCRIPTION         = "Retrieved pressure (Pa)"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
  COLUMN_NUMBER       = 38
  NAME                = P_RET_ERR
  DATA_TYPE          = ASCII_REAL
  START_BYTE          = 482
  BYTES               = 10
  DESCRIPTION         = "Retrieved pressure uncertainty (Pa)"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
  COLUMN_NUMBER       = 39
  NAME                = RQUAL
  DATA_TYPE          = ASCII_INTEGER
  START_BYTE          = 493
  BYTES               = 6
  DESCRIPTION         = "Radiance Quality Flag"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
  COLUMN_NUMBER       = 40
  NAME                = P_QUAL
  DATA_TYPE          = ASCII_INTEGER
  START_BYTE          = 500
  BYTES               = 7
  DESCRIPTION         = "Pressure retrieval quality flag."
END_OBJECT            = COLUMN

OBJECT                = COLUMN
  COLUMN_NUMBER       = 41
  NAME                = T_QUAL
  DATA_TYPE          = ASCII_INTEGER
  START_BYTE          = 508
  BYTES               = 7
  DESCRIPTION         = "Temperature retrieval quality flag."
END_OBJECT            = COLUMN

OBJECT                = COLUMN
  COLUMN_NUMBER       = 42
  NAME                = DUST_QUAL
  DATA_TYPE          = ASCII_INTEGER
  START_BYTE          = 516
  BYTES               = 10
  DESCRIPTION         = "Dust retrieval quality flag."
END_OBJECT            = COLUMN

OBJECT                = COLUMN
  COLUMN_NUMBER       = 43
  NAME                = H2OVAP_QUAL
  DATA_TYPE          = ASCII_INTEGER
  START_BYTE          = 527
  BYTES               = 13
  DESCRIPTION         = "Water vapor retrieval quality flag."
END_OBJECT            = COLUMN

OBJECT                = COLUMN
  COLUMN_NUMBER       = 44
  NAME                = H2OICE_QUAL
  DATA_TYPE          = ASCII_INTEGER
  START_BYTE          = 541
  BYTES               = 13
  DESCRIPTION         = "Water ice retrieval quality flag."
END_OBJECT            = COLUMN

OBJECT                = COLUMN

```

```

COLUMN_NUMBER      = 45
NAME               = CO2ICE_QUAL
DATA_TYPE          = ASCII_INTEGER
START_BYTE         = 555
BYTES              = 13
DESCRIPTION        = "CO2 ice retrieval quality flag."
END_OBJECT         = COLUMN

OBJECT             = COLUMN
COLUMN_NUMBER      = 46
NAME               = SURF_QUAL
DATA_TYPE          = ASCII_INTEGER
START_BYTE         = 569
BYTES              = 10
DESCRIPTION        = "Surface/near surface retrieval quality flag."
END_OBJECT         = COLUMN

OBJECT             = COLUMN
COLUMN_NUMBER      = 47
NAME               = OBS_QUAL
DATA_TYPE          = ASCII_INTEGER
START_BYTE         = 580
BYTES              = 10
DESCRIPTION        = "Quality of the observation set used for the retrieval."
END_OBJECT         = COLUMN

OBJECT             = COLUMN
COLUMN_NUMBER      = 48
NAME               = REF_SCLK_0
DATA_TYPE          = ASCII_REAL
START_BYTE         = 591
BYTES              = 14
DESCRIPTION        = "The MRO Spacecraft Clock, without partition, including decimal
thousandths of a second; record n [0 to 9] from RDR used in the retrieval."
END_OBJECT         = COLUMN

OBJECT             = COLUMN
COLUMN_NUMBER      = 49
NAME               = REF_SCLK_1
DATA_TYPE          = ASCII_REAL
START_BYTE         = 606
BYTES              = 14
DESCRIPTION        = "The MRO Spacecraft Clock, without partition, including decimal
thousandths of a second; record n [0 to 9] from RDR used in the retrieval."
END_OBJECT         = COLUMN

OBJECT             = COLUMN
COLUMN_NUMBER      = 50
NAME               = REF_SCLK_2
DATA_TYPE          = ASCII_REAL
START_BYTE         = 621
BYTES              = 14
DESCRIPTION        = "The MRO Spacecraft Clock, without partition, including decimal
thousandths of a second; record n [0 to 9] from RDR used in the retrieval."
END_OBJECT         = COLUMN

OBJECT             = COLUMN
COLUMN_NUMBER      = 51
NAME               = REF_SCLK_3
DATA_TYPE          = ASCII_REAL
START_BYTE         = 636
BYTES              = 14
DESCRIPTION        = "The MRO Spacecraft Clock, without partition, including decimal
thousandths of a second; record n [0 to 9] from RDR used in the retrieval."
END_OBJECT         = COLUMN

OBJECT             = COLUMN
COLUMN_NUMBER      = 52
NAME               = REF_SCLK_4
DATA_TYPE          = ASCII_REAL
START_BYTE         = 651
BYTES              = 14
DESCRIPTION        = "The MRO Spacecraft Clock, without partition, including decimal

```

```

        thousandths of a second; record n [0 to 9] from RDR used in the retrieval."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
COLUMN_NUMBER   = 53
NAME            = REF_SCLK_5
DATA_TYPE       = ASCII_REAL
START_BYTE      = 666
BYTES           = 14
DESCRIPTION      = "The MRO Spacecraft Clock, without partition, including decimal
        thousandths of a second; record n [0 to 9] from RDR used in the retrieval."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
COLUMN_NUMBER   = 54
NAME            = REF_SCLK_6
DATA_TYPE       = ASCII_REAL
START_BYTE      = 681
BYTES           = 14
DESCRIPTION      = "The MRO Spacecraft Clock, without partition, including decimal
        thousandths of a second; record n [0 to 9] from RDR used in the retrieval."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
COLUMN_NUMBER   = 55
NAME            = REF_SCLK_7
DATA_TYPE       = ASCII_REAL
START_BYTE      = 696
BYTES           = 14
DESCRIPTION      = "The MRO Spacecraft Clock, without partition, including decimal
        thousandths of a second; record n [0 to 9] from RDR used in the retrieval."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
COLUMN_NUMBER   = 56
NAME            = REF_SCLK_8
DATA_TYPE       = ASCII_REAL
START_BYTE      = 711
BYTES           = 14
DESCRIPTION      = "The MRO Spacecraft Clock, without partition, including decimal
        thousandths of a second; record n [0 to 9] from RDR used in the retrieval."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
COLUMN_NUMBER   = 57
NAME            = REF_SCLK_9
DATA_TYPE       = ASCII_REAL
START_BYTE      = 726
BYTES           = 14
DESCRIPTION      = "The MRO Spacecraft Clock, without partition, including decimal
        thousandths of a second; record n [0 to 9] from RDR used in the retrieval."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
COLUMN_NUMBER   = 58
NAME            = REF_DATE_0
DATA_TYPE       = CHARACTER
START_BYTE      = 741
BYTES           = 14
DESCRIPTION      = "Date of measurement (UTC); record n [0 to 9] from RDR used in
        the retrieval."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
COLUMN_NUMBER   = 59
NAME            = REF_UTC_0
DATA_TYPE       = CHARACTER
START_BYTE      = 756
BYTES           = 15
DESCRIPTION      = "Time of measurement (UTC); record n [0 to 9] from RDR used in
        the retrieval."
END_OBJECT      = COLUMN

```

```

OBJECT                = COLUMN
  COLUMN_NUMBER       = 60
  NAME                = REF_DATE_1
  DATA_TYPE          = CHARACTER
  START_BYTE          = 772
  BYTES               = 14
  DESCRIPTION         = "Date of measurement (UTC); record n [0 to 9] from RDR used in
                        the retrieval."
END_OBJECT            = COLUMN

OBJECT                = COLUMN
  COLUMN_NUMBER       = 61
  NAME                = REF_UTC_1
  DATA_TYPE          = CHARACTER
  START_BYTE          = 787
  BYTES               = 15
  DESCRIPTION         = "Time of measurement (UTC); record n [0 to 9] from RDR used in
                        the retrieval."
END_OBJECT            = COLUMN

OBJECT                = COLUMN
  COLUMN_NUMBER       = 62
  NAME                = REF_DATE_2
  DATA_TYPE          = CHARACTER
  START_BYTE          = 803
  BYTES               = 14
  DESCRIPTION         = "Date of measurement (UTC); record n [0 to 9] from RDR used in
                        the retrieval."
END_OBJECT            = COLUMN

OBJECT                = COLUMN
  COLUMN_NUMBER       = 63
  NAME                = REF_UTC_2
  DATA_TYPE          = CHARACTER
  START_BYTE          = 818
  BYTES               = 15
  DESCRIPTION         = "Time of measurement (UTC); record n [0 to 9] from RDR used in
                        the retrieval."
END_OBJECT            = COLUMN

OBJECT                = COLUMN
  COLUMN_NUMBER       = 64
  NAME                = REF_DATE_3
  DATA_TYPE          = CHARACTER
  START_BYTE          = 834
  BYTES               = 14
  DESCRIPTION         = "Date of measurement (UTC); record n [0 to 9] from RDR used in
                        the retrieval."
END_OBJECT            = COLUMN

OBJECT                = COLUMN
  COLUMN_NUMBER       = 65
  NAME                = REF_UTC_3
  DATA_TYPE          = CHARACTER
  START_BYTE          = 849
  BYTES               = 15
  DESCRIPTION         = "Time of measurement (UTC); record n [0 to 9] from RDR used in
                        the retrieval."
END_OBJECT            = COLUMN

OBJECT                = COLUMN
  COLUMN_NUMBER       = 66
  NAME                = REF_DATE_4
  DATA_TYPE          = CHARACTER
  START_BYTE          = 865
  BYTES               = 14
  DESCRIPTION         = "Date of measurement (UTC); record n [0 to 9] from RDR used in
                        the retrieval."
END_OBJECT            = COLUMN

OBJECT                = COLUMN
  COLUMN_NUMBER       = 67
  NAME                = REF_UTC_4

```

```

DATA_TYPE           = CHARACTER
START_BYTE          = 880
BYTES               = 15
DESCRIPTION          = "Time of measurement (UTC); record n [0 to 9] from RDR used in
the retrieval."
END_OBJECT           = COLUMN

OBJECT              = COLUMN
COLUMN_NUMBER        = 68
NAME                 = REF_DATE_5
DATA_TYPE            = CHARACTER
START_BYTE           = 896
BYTES                = 14
DESCRIPTION           = "Date of measurement (UTC); record n [0 to 9] from RDR used in
the retrieval."
END_OBJECT           = COLUMN

OBJECT              = COLUMN
COLUMN_NUMBER        = 69
NAME                 = REF_UTC_5
DATA_TYPE            = CHARACTER
START_BYTE           = 911
BYTES                = 15
DESCRIPTION           = "Time of measurement (UTC); record n [0 to 9] from RDR used in
the retrieval."
END_OBJECT           = COLUMN

OBJECT              = COLUMN
COLUMN_NUMBER        = 70
NAME                 = REF_DATE_6
DATA_TYPE            = CHARACTER
START_BYTE           = 927
BYTES                = 14
DESCRIPTION           = "Date of measurement (UTC); record n [0 to 9] from RDR used in
the retrieval."
END_OBJECT           = COLUMN

OBJECT              = COLUMN
COLUMN_NUMBER        = 71
NAME                 = REF_UTC_6
DATA_TYPE            = CHARACTER
START_BYTE           = 942
BYTES                = 15
DESCRIPTION           = "Time of measurement (UTC); record n [0 to 9] from RDR used in
the retrieval."
END_OBJECT           = COLUMN

OBJECT              = COLUMN
COLUMN_NUMBER        = 72
NAME                 = REF_DATE_7
DATA_TYPE            = CHARACTER
START_BYTE           = 958
BYTES                = 14
DESCRIPTION           = "Date of measurement (UTC); record n [0 to 9] from RDR used in
the retrieval."
END_OBJECT           = COLUMN

OBJECT              = COLUMN
COLUMN_NUMBER        = 73
NAME                 = REF_UTC_7
DATA_TYPE            = CHARACTER
START_BYTE           = 973
BYTES                = 15
DESCRIPTION           = "Time of measurement (UTC); record n [0 to 9] from RDR used in
the retrieval."
END_OBJECT           = COLUMN

OBJECT              = COLUMN
COLUMN_NUMBER        = 74
NAME                 = REF_DATE_8
DATA_TYPE            = CHARACTER
START_BYTE           = 989
BYTES                = 14

```

```

    DESCRIPTION      = "Date of measurement (UTC); record n [0 to 9] from RDR used in
    the retrieval."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
COLUMN_NUMBER       = 75
NAME                = REF.UTC_8
DATA_TYPE           = CHARACTER
START_BYTE          = 1004
BYTES               = 15
DESCRIPTION          = "Time of measurement (UTC); record n [0 to 9] from RDR used in
    the retrieval."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
COLUMN_NUMBER       = 76
NAME                = REF.DATE_9
DATA_TYPE           = CHARACTER
START_BYTE          = 1020
BYTES               = 14
DESCRIPTION          = "Date of measurement (UTC); record n [0 to 9] from RDR used in
    the retrieval."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
COLUMN_NUMBER       = 77
NAME                = REF.UTC_9
DATA_TYPE           = CHARACTER
START_BYTE          = 1035
BYTES               = 14
DESCRIPTION          = "Time of measurement (UTC); record n [0 to 9] from RDR used in
    the retrieval."
END_OBJECT          = COLUMN

```

B.2 Example Data Product Format File

```

OBJECT          = COLUMN
  COLUMN_NUMBER = 1
  NAME          = 1
  DATA_TYPE    = ASCII_INTEGER
  START_BYTE    = 1
  BYTES         = 1
  DESCRIPTION    = "A quality indicator:  0 means this record contains valid data."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 2
  NAME          = PRES
  DATA_TYPE    = ASCII_REAL
  START_BYTE    = 3
  BYTES         = 13
  DESCRIPTION    = "Pressure surface for this layer of the profile (Pa).
    The pressures calculated from  $p(i) = p_0 \exp(-.125 \cdot (i-10))$ ,
     $i = 1..100$  where  $p_0 = 610.$ "
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  COLUMN_NUMBER = 3
  NAME          = T
  DATA_TYPE    = ASCII_REAL
  START_BYTE    = 17
  BYTES         = 8
  DESCRIPTION    = "Temperature on the pressure surface (K)."

```

```

COLUMN_NUMBER      = 8
NAME               = H2OVAP_ERR
DATA_TYPE          = ASCII_REAL
START_BYTE         = 71
BYTES              = 11
DESCRIPTION        = "Water vapor uncertainty on the pressure surface
                      (volume mixing ratio, ppm)."
```

END_OBJECT = COLUMN

```

OBJECT             = COLUMN
COLUMN_NUMBER      = 9
NAME               = H2OICE
DATA_TYPE          = ASCII_REAL
START_BYTE         = 83
BYTES              = 11
DESCRIPTION        = "Water ice opacity per km on the pressure surface
                      at 843 wavenumbers (or 11.9 microns)."
```

END_OBJECT = COLUMN

```

OBJECT             = COLUMN
COLUMN_NUMBER      = 10
NAME               = H2OICE_ERR
DATA_TYPE          = ASCII_REAL
START_BYTE         = 95
BYTES              = 11
DESCRIPTION        = "Water ice opacity uncertainty on the pressure
                      surface (opacity per km in at 843 wavenumbers or 11.9 microns)."
```

END_OBJECT = COLUMN

```

OBJECT             = COLUMN
COLUMN_NUMBER      = 11
NAME               = CO2ICE
DATA_TYPE          = ASCII_REAL
START_BYTE         = 107
BYTES              = 11
DESCRIPTION        = "CO2 ice opacity per km on the pressure surface
                      at xxx wavenumbers (or yyy microns)."
```

END_OBJECT = COLUMN

```

OBJECT             = COLUMN
COLUMN_NUMBER      = 12
NAME               = CO2ICE_ERR
DATA_TYPE          = ASCII_REAL
START_BYTE         = 119
BYTES              = 11
DESCRIPTION        = "CO2 ice opacity uncertainty on the pressure
                      surface (opacity per km at xxx wavenumbers or yyy microns)."
```

END_OBJECT = COLUMN

```

OBJECT             = COLUMN
COLUMN_NUMBER      = 13
NAME               = ALT
DATA_TYPE          = ASCII_REAL
START_BYTE         = 131
BYTES              = 8
DESCRIPTION        = "Altitude of the pressure surface above the
                      surface point (DDR1, column 21) (km)."
```

END_OBJECT = COLUMN

```

OBJECT             = COLUMN
COLUMN_NUMBER      = 14
NAME               = LAT
DATA_TYPE          = ASCII_REAL
START_BYTE         = 140
BYTES              = 10
DESCRIPTION        = "Latitude of the center of the measurement
                      region on the pressure surface (deg)."
```

END_OBJECT = COLUMN

```

OBJECT             = COLUMN
COLUMN_NUMBER      = 15
NAME               = LON
DATA_TYPE          = ASCII_REAL
```



```
START_BYTE      = 151
BYTES           = 10
DESCRIPTION      = "Longitude of the center of the measurement
                    region on the pressure surface (deg)."
```

END_OBJECT = COLUMN