D-64069

OCO (Orbiting Carbon Observatory) Project
OCO-2

Software Interface Specification for the SDOS Level 2 Standard Product

Revision C
June 20, 2015

Paper copies of this document may not be current and should not be relied on for official purposes. The current version is in Product Data Management System: https://pdms.jpl.nasa.gov.

National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology

Prepared by:

_____ _____

Charles Avis Date
Manager, OCO-2 Science Data Operations System

Reviewed by:

_____ _____

Bruce Vollmer Date
GES DISC Mission Support Lead

*** Original signature page on file in project physical repository ***

© 2015 California Institute of Technology. Government sponsorship acknowledged.

Change Log

Revision	Date	Sections Changed	Author
Initial	May 15, 2014		
Rev A	July 29, 2014	1, 3, 4.1,4.2, 5, 6	Chafin
Rev B	March 15, 2015	1, 5, 6, Appendix 1, 2	C. Avis
Rev C	June 20, 2015	1 (applicable version), 3 (changed reference documents to those accessible to public), 4.2 (added CalibType), 5 (9 new eof3… fields in RetrievalResults groups, 9 new …spacing…fields in DispersionResults group, update to bit 4 of sounding_qual_flag)	C. Avis

Table of Contents

1 Product Identification and Software Version 1
2 Background information 1
2.1 NASA Data Levels 1
2.2 Product Pedigree and Destination 1
2.3 Suggested Tools to Read Product 2
3 Reference Documents (at http://disc.sci.gsfc.nasa.gov/OCO-2/documentation) 2
4 Product Description 2
4.1 Format and Size 2
4.2 Naming Convention 2
5 Specification Table 4
6 Appendix 1: Shape Descriptions 23
7 Appendix 2: Acronyms 24

1 Product Identification and Software Version

This document describes the specification of one of the data products generated by the OCO-2 Science Data Operations System (SDOS). This document applies to the following product and system version:

Product Name:	Level 2 Standard Product
Short Name:	OCO2_L2_Standard
SDOS System Version:	B7.0.00 and later
GES DISC Version:	Version 7 and Version 7r and later
Product Description:	Geolocated retrieved state vectors with CO2-column averaged dry air mole fraction using 3-band full physics retrieval (includes Full-physics algorithm results that provide details of algorithm performance)

SDOS System Bn.0.00 generates products either with predictive calibration parameters (Version n) or with parameters derived via analysis of past instrument performance (Version nr). Therefore, nr is considered of higher quality. Analyses mixing the two sets should be undertaken with a degree of caution. The product specifications for n and nr are identical and this document applies to both.

2 Background information

The OCO-2 SDOS converts telemetry downloaded from the Observatory into data products that provide comprehensive mission results as well as material for further research and investigation. The SDOS generates products from Level 0 through Level 2, some of which are available for distribution to both the scientific community and the general public. All products are available to users of the SDOS computing cluster.

2.1 NASA Data Levels

The following table provides the definitions of the data levels used in this document. These definitions are standard within the NASA community

Level	Description
Packet data	Telemetry data stream as received at the ground station, with science and engineering data embedded
Level 0	Instrument science data (e.g., raw voltages, counts) at full resolution, time ordered, with duplicates and transmission errors removed
Level 1A	NASA 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	Irreversibly transformed (e.g., resampled, remapped, calibrated) values of the instrument measurements (e.g., radiances, magnetic field strength)
Level 2	Geophysical parameters, generally derived from NASA Level 1 data, and located in space and time commensurate with instrument location, pointing, and sampling

2.2 Product Pedigree and Destination

This product is generated within the nominal SDOS pipeline by the Subfielder PGE using the following input data:

- Level 2 Diagnostic product

This product is expected to be an input to the following PGE's within the nominal SDOS pipeline:

- N/A

2.3 Suggested Tools to Read Product

The following set of tools can be used to open and examine this HDF-5 product on Linux systems. Other tools may be available.

- h5dump
- hdfview

3 Reference Documents (at http://disc.sci.gsfc.nasa.gov/OCO-2/documentation)

1. Level 2 Full Physics Retrieval ATBD
2. Data Users Guide
3. Data Quality Statement

4 Product Description

4.1 Format and Size

This product is in HDF-5 format. For most nominal orbits, the product will use up to 600 megabytes.

4.2 Naming Convention

oco2_[*ProductId*][*Mode*]_[*Orbit*][*ModeCounter*]_[*AcquisitionDate*]_[*ShortBuildId*][*CalibType*]_[*ProductionDateTime*].h5

Field	Description	Format	Selection
ProductId	A mnemonic indicating a file type.	String	L2Std - Level 2 Standard Product
Mode	The acquisition Mode associated with the data.	Two character string	GL - Sample Glint
			ND - Sample Nadir
			TG - Sample Target
			XS - Sample Transition
Orbit	The Orbit on which the associated data	nnnnn	Actual Orbit number for data acquired

	were acquired. If the Orbit number is less than 10,000, zeros are prepended to the number to ensure that the field is five digits long.		during operations
ModeCounter	This field indicates how many times an acquisition Mode occurs in an Orbit. If a mode occurs only once, ModeCounter is set to "a".	Single character	a, b, c, …
AcquisitionDate	The date (UTC) the data were acquired.	yymmdd	
ShortBuildId	The identification of the related software build	Bstuu	s = ID of major build cycle t = ID of scheduled build within a major build cycle uu = ID of incremental or patch build
CalibType	Indicates whether processing used predictive or retrospective calibration	Single character if retrospective; Not present if predictive	r = retrospective calibration used
ProductionDateTime	The date and time (UTC) that the file was produced.	yymmddhhmmss	

5 Specification Table

The HDF file structure consists of a large number of Data Elements with values. These Elements (a.k.a., 'fields') may be of various types (e.g., arrays, scalars) and are organized into Groups. Groups are utilized in various ways, such as to combine Elements/values generated by different PGE's.

Description of column headers in the following tables:

Data Element	The name of the Data Element
Shape	See Appendix 1
Type	The data type of the values
Units	The SI units of the values, if any
Minimum value	The lowest possible value. In some cases, this is the lowest safe value (i.e., a 'red' limit)
Maximum value	The highest possible value. In some cases, this is the highest safe value (i.e., a 'red' limit)
Comments	Descriptive information about the Element
(no value = n/a)	

L2_Standard Product HDF specification

Group	**Metadata**					
Group description	Granule-level Metadata					
Data Element	**Shape**	**Type**	**Units**	**Minimum value**	**Maximum value**	**Comments**
Standard Metadata	See OCO-2 Standard Metadata specification table below					
AbscoCO2Scale	Spectrum_Array	Float32				Empirical scaling factors for CO2 ABSCO tables. Values should be different for the 1.6 micron and 2.06 micron bands and were chosen to provide agreement of retrieved XCO2 with TCCON XCO2.
AbscoH2OScale	Spectrum_Array	Float32				Empirical scaling factor for H2O ABSCO tables. Currently should be 1.0.
AbscoO2Scale	Spectrum_Array	Float32				Empirical scaling factor for O2 ABSCO tables. Values chosen to improve agreement between retrieved surface pressure and independent estimates from a numerical weather prediction model.
AcquisitionMode	Scalar	String				The instrument mode in which the data in the product were collected. Valid values are: 'Glint', 'Nadir', 'Target', 'Sample Dark Calibration', 'Sample Lamp Calibration', 'Sample Solar/limb Calibration', 'Single-Pixel Dark Calibration', 'Single-Pixel Lamp Calibration', 'Single-Pixel Solar/limb Calibration'
ActualFrames	Scalar	Int32				Actual number of frames reported in this product
ActualGoodRetrievals	Scalar	Int32				Actual number of reported retrievals with a "Good" quality flag
ActualRetrievals	Scalar	Int32				Actual number of retrievals reported in the product
ARPAncillaryDatasetDescriptor	Scalar	String				The name of the Ancillary Radiometric Product file used to calibrate this file
AscendingEquatorCrossingDate	Scalar	String				The date of the equator crossing of the spacecraft ground track in the ascending direction

AscendingEquatorCrossingLongitude	Scalar	Float32	Degrees	-180	180	The longitude of the equator crossing of the spacecraft ground track in the ascending direction
AscendingEquatorCrossingTime	Scalar	String				The time of the equator crossing of the spacecraft ground track in the ascending direction
EphemerisType	Scalar	String				The source of the spacecraft ephemeris data that were utilized to generate this data file
EquatorCrossingDate	Scalar	String				The date of the equator crossing of the spacecraft ground track in the descending direction
EquatorCrossingLongitude	Scalar	Float32	Degrees	-180	180	The longitude of the equator crossing of the spacecraft ground track in the descending direction
EquatorCrossingTime	Scalar	String				The time of the equator crossing of the spacecraft ground track in the descending direction
ExpectedFrames	Scalar	Int32				Nominal number of frames in this product
FirstSoundingId	Scalar	Int64				The ID of the first sounding in this file
L2FullPhysicsAlgorithmDescriptor	Scalar	String				Identification of the algorithm and version used to generate this product
L2FullPhysicsDataVersion	Scalar	String				The source of the data used by the Full-physics algorithm: 'r01' - initial processing; 'r02', 'r03', etc. - reprocessed data
L2FullPhysicsExeVersion	Scalar	String				The build version number of the Full-physics algorithm used to generate this product
L2FullPhysicsProductionLocation	Scalar	String				Facility in which Full Physics code was run, typically: 'JPL', 'Pleiades'
L2FullPhysicsInputPointer	L2FullPhysicsInputPtr_Array	String				Pointer to one or more data granules and auxilliary files that provide the major input that was used to generate this product
LastSoundingId	Scalar	Int64				The ID of the last sounding in this file
ModeCounter	Scalar	String				The Nth occurrence of this particular mode for this orbit, indicated by letter ('a', 'b', 'c', 'd', etc.)
OperationMode	Scalar	String				The two-letter abbreviation of the AcquisitionMode: GL, ND, TG, DS, LS, SS, BS, NP, GP, TP, DP, LP, SP, BP, XS, XP, MS, MP, SB
OrbitEccentricity	Scalar	Float32				The eccentricity of the spacecraft orbital path
OrbitInclination	Scalar	Float32	Degrees	0	180	The angle between the plane of the spacecraft orbital path and the Earth equatorial plane
OrbitParametersPointer	OrbitParamPtr_Array	String				The data files that provided the orbit parameters used to generate this product
OrbitPeriod	Scalar	Float32	Seconds			The time span between two consecutive descending node crossings
OrbitSemiMajorAxis	Scalar	Float32	Meters			The length of the semimajor axis of the spacecraft orbit
OrbitStartDate	Scalar	String				The date of the equator crossing of the spacecraft nadir track in the descending direction
OrbitStartLongitude	Scalar	Float32	Degrees	-180	180	The longitude of the equator crossing of the spacecraft ground track in the descending direction
OrbitStartTime	Scalar	String				The time of the equator crossing of the spacecraft ground track in the descending direction
RadianceConversionFactor	Scalar	Float32	Ph sec^{-1} W^{-1}			Multiplicative factor used to convert W m^{-2} sr^{-1} um^{-1} to Ph sec^{-1} m^{-2} sr^{-1} um^{-1} at 760 nm (38.228x10^17)

ReportedSoundings	SoundingPosition_Array	Int8		0	1	Indicates the inclusion of each footprint in the data: 0 - not included, 1 - included
RetrievalIterationLimit	Scalar	Int32				Maximum number of iterations allowed before the algorithm gives up and sets the outcome_flag to 3
SpectralChannel	Spectrum_Array	String				A description of the spectral channels used for the measurements
VMRO2	Scalar	Float32	Mole Mole^{-1}			The volume mixing ratio of atmospheric O_2
Group	**L1bScSoundingReference**					
Group description	Metadata applying to every sounding in source L1bSc product					
Data Element	**Shape**	**Type**	**Units**	**Minimum value**	**Maximum value**	**Comments**
sounding_id_l1b	Frame_Sounding_Array	Int64				Unique identifier for each sounding
sounding_qual_flag	Frame_Sounding_Array	UInt64				Bit flags indicating the quality of the data in sounding: 0 - Good, non-zero - see documentation
packaging_qual_flag	Frame_Sounding_Array	UInt8				Bit flags recording errors during packaging of L2 Full-physics and preprocessing output into retrieval arrays: 0 - Good, non-zero - see documentation
retrieval_index	Frame_Sounding_Array	Int32				The index into the Retrieval dimension of arrays in the RetrievalResults, RetrievedStateVector, and SpectralParameters groups for soundings associated with retrievals
Group	**L1bScSpectralParameters**					
Group description	Spectral parameters derived in the L1b process applying to every sounding in source L1bSc product					
Data Element	**Shape**	**Type**	**Units**	**Minimum value**	**Maximum value**	**Comments**
snr_o2_l1b	Retrieval_Array	Float32				The mean signal-to-noise ratio of the good samples in the band falling between the 98th and 99th percentile for signal level
snr_weak_co2_l1b	Retrieval_Array	Float32				The mean signal-to-noise ratio of the good samples in the band falling between the 98th and 99th percentile for signal level
snr_strong_co2_l1b	Retrieval_Array	Float32				The mean signal-to-noise ratio of the good samples in the band falling between the 98th and 99th percentile for signal level
spike_eof_bad_colors_o2	Retrieval_Array	Int16				Number of bad colors in the ABO2 spectrum
spike_eof_bad_colors_weak_co2	Retrieval_Array	Int16				Number of bad colors in the WCO2 spectrum
spike_eof_bad_colors_strong_co2	Retrieval_Array	Int16				Number of bad colors in the SCO2 spectrum
max_declocking_factor_o2	Retrieval_Array	Float32				Maximum clocking correction factor of the ABO2 spectrum
max_declocking_factor_weak_co2	Retrieval_Array	Float32				Maximum clocking correction factor of the WCO2 spectrum
max_declocking_factor_strong_co2	Retrieval_Array	Float32				Maximum clocking correction factor of the SCO2 spectrum

rad_mean_spectra_o2	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			The mean radiance of the ABO2 spectrum
rad_mean_spectra_weak_co2	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			The mean radiance of the WCO2 spectrum
rad_mean_spectra_strong_co2	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			The mean radiance of the SCO2 spectrum
rad_stddev_spectra_o2	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			The standard deviation of the radiance of the ABO2 spectrum
rad_stddev_spectra_weak_co2	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			The standard deviation of the radiance of the WCO2 spectrum
rad_stddev_spectra_strong_co2	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			The standard deviation of the radiance of the SCO2 spectrum
Group	**RetrievalHeader**					
Group description	Metadata applying to every retrieval result					
Data Element	**Shape**	**Type**	**Units**	**Minimum value**	**Maximum value**	**Comments**
sounding_id	Retrieval_Array	Int64				The sounding_id of the sounding containing the spectra used to perform the retrieval
frame_index	Retrieval_Array	Int32				Index of the frame dimension of the corresponding sounding in L1bScSoundingReference data elements
sounding_index	Retrieval_Array	Int32				Index of the sounding dimension of the corresponding sounding in the L1bScSoundingReference data elements
retrieval_time_string	Retrieval_Array	String				Data acquisition time for the retrieval based upon the three footprint times (yyyy-mm-ddThh:mm:ss.mmmZ)
retrieval_time_tai93	Retrieval_Array	Float64	Seconds			Data acquisition time for the retrieval based upon the three footprint times in seconds since Jan. 1, 1993
warn_level	Retrieval_Array	Int8		0	20	Value predicted by modeling indicating the likely quality of the retrieval result: 0 - 'Very high quality', … ,19 - 'Very low quality'
Group	**RetrievalGeometry**					
Group description	Geometric information that applies to individual soundings					
Data Element	**Shape**	**Type**	**Units**	**Minimum value**	**Maximum value**	**Comments**
retrieval_altitude	Retrieval_Array	Float32	Meters			Altitude of the sounding based on Earth topography
retrieval_altitude_uncert	Retrieval_Array	Float32	Meters			Uncertainty of the source Earth topography data
retrieval_aspect	Retrieval_Array	Float32	Degrees	0	360	Orientation of the surface slope relative to the local North

retrieval_azimuth	Retrieval_Array	Float32	Degrees	0	360	Angle between the LOS as defined from the sounding location to the spacecraft, and the sounding location local north direction
retrieval_center_offset_o2_weak_co2	Retrieval_Array	Float32	Meters			Distance between the ABO2 band footprint center and the WCO2 band footprint center
retrieval_center_offset_strong_co2_o2	Retrieval_Array	Float32	Meters			Distance between the SCO2 band footprint center and the ABO2 band footprint center
retrieval_center_offset_weak_co2_strong_co2	Retrieval_Array	Float32	Meters			Distance between the WCO2 band footprint center and the SCO2 band footprint center
retrieval_land_fraction	Retrieval_Array	Float32	Percent	0	100	Percentage of land surface type within the sounding
retrieval_land_water_indicator	Retrieval_Array	Int8		0	3	Surface type at the sounding location: 0 - Land, 1 - Water, 2 - unused, 3 - Mixed land water
retrieval_latitude	Retrieval_Array	Float32	Degrees	-90	90	Geodetic latitude of the sounding based on Earth topography
retrieval_latitude_geoid	Retrieval_Array	Float32	Degrees	-90	90	Geodetic latitude of the sounding based on standard geoid
retrieval_longitude	Retrieval_Array	Float32	Degrees	-180	180	Longitude of the sounding based on Earth topography
retrieval_longitude_geoid	Retrieval_Array	Float32	Degrees	-180	180	Longitude of the sounding based on standard geoid
retrieval_overlap	Retrieval_Array	Float32	Percent	0	100	Area of intersection of all three band footprints relative to average area of all three band footprints
retrieval_overlap_o2_weak_co2	Retrieval_Array	Float32	Percent	0	100	Area of intersection of the footprints of ABO2 and WCO2 relative to the average area of the two footprint
retrieval_overlap_strong_co2_o2	Retrieval_Array	Float32	Percent	0	100	Area of intersection of the footprints of ABO2 and SCO2 relative to the average area of the two footprints
retrieval_overlap_weak_co2_strong_co2	Retrieval_Array	Float32	Percent	0	100	Area of intersection of the footprints of WCO2 and SCO2 relative to the average area of the two footprints
retrieval_plane_fit_quality	Retrieval_Array	Float32	Meters			Goodness-of-fit of surface slope: the standard deviation of the points, to which the plane is fitted, with the expected values taken as the orthogonal projection of the points onto the plane
retrieval_polarization_angle	Retrieval_Array	Float32	Degrees	0	360	The angle between the accepted polarization axis of the instrument and the instrument reference plane for polarization, defined as the plane formed by the LOS and the ray from the sounding location to the local zenith
retrieval_relative_velocity	Retrieval_Array	Float32	Meters Second^{-1}			Velocity of the spacecraft along the LOS: positive indicates spacecraft moving toward sounding location
retrieval_slant_path_diff_o2_weak_co2	Retrieval_Array	Float32	Meters			Difference in slant path between ABO2 and WCO2 footprints
retrieval_slant_path_diff_strong_co2_o2	Retrieval_Array	Float32	Meters			Difference in slant path between SCO2 and ABO2 footprints
retrieval_slant_path_diff_weak_co2_strong_co2	Retrieval_Array	Float32	Meters			Difference in slant path between WCO2 and SCO2 footprints
retrieval_slope	Retrieval_Array	Float32	Degrees	0	180	Slope of a plane fit to points within the sounding
retrieval_solar_azimuth	Retrieval_Array	Float32	Degrees	0	360	Angle between the solar direction as defined from the sounding location to the Sun, and the sounding location local North direction
retrieval_solar_distance	Retrieval_Array	Float64	Meters			Distance between sounding location and the Sun

retrieval_solar_relative_velocity	Retrieval_Array	Float32	Meters Second^{-1}			Velocity of the Sun along the sounding location/Sun vector: negative indicates Sun moving toward sounding location
retrieval_solar_zenith	Retrieval_Array	Float32	Degrees	0	180	Angle between the solar direction as defined from the sounding location to the Sun, and the sounding location local zenith direction
retrieval_surface_roughness	Retrieval_Array	Float32	Meters			Standard deviation of the altitude within the sounding
retrieval_vertex_latitude	Retrieval_Spectrum_Vertex_Array	Float32	Degrees	-90	90	Geodetic latitude of the footprint vertices using Earth topography
retrieval_vertex_longitude	Retrieval_Spectrum_Vertex_Array	Float32	Degrees	-180	180	Longitude of the footprint vertices using Earth topography
retrieval_zenith	Retrieval_Array	Float32	Degrees	0	180	Angle between the LOS as defined from the sounding location to the spacecraft, and the sounding location local zenith direction
Group	**PreprocessingResults**					
Group description	Results from A-Band Retrieval Preprocessing and IMAP-DOAS Preprocessing for soundings generating retrievals					
Data Element	**Shape**	**Type**	**Units**	**Minimum value**	**Maximum value**	**Comments**
albedo_o2_abp	Retrieval_AlbedoWavelength_Array	Float32				O_2 albedo at 785 and 755 nm
dispersion_multiplier_abp	Retrieval_Array	Float64				A number retrieved by the ABO2 algorithm that multiplies the dispersion coefficients as given in the L1B input file to get the effective wavelength of each channel
reduced_chi_squared_o2_abp	Retrieval_Array	Float32				O_2 reduced chi squared retrieved by ABO2 preprocessing
reduced_chi_squared_o2_threshold_abp	Retrieval_Array	Float32				Threshold of O_2 reduced chi squared used to set cloud_flag
noise_o2_abp	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			O2 measurement noise retrieved by the ABO2 algorithm
signal_o2_abp	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			O2 measurement signal level retrieved by the ABO2 algorithm
snr_o2_abp	Retrieval_Array	Float32				O2 measurement SNR retrieved by the ABO2 algorithm
surface_pressure_apriori_abp	Retrieval_Array	Float32	Pascals			*a priori* surface pressure used by the ABO2 algorithm
surface_pressure_offset_abp	Retrieval_Array	Float32	Pascals			Empirically determined value to be added to the A-band retrieved surface pressure, such that their sum is unbiased in clear scenes. It is modeled as a piecewise linear function of solar zenith angle; separate functions are used for land vs. ocean pixels.
surface_pressure_abp	Retrieval_Array	Float32	Pascals			Surface pressure retrieved by the ABO2 algorithm
surface_pressure_delta_abp	Retrieval_Array	Float32	Pascals			The value of surface_pressure_abp minus surface_pressure_apriori_abp and surface_pressure_offset_abp
temperature_offset_abp	Retrieval_Array	Float32	Kelvins			The offset to the prior meteorological temperature profile as retrieved by the ABO2 algorithm

dry_air_column_apriori_idp	Retrieval_Array	Float32	Molecules Meters^{-2}			Integrated vertical column of dry airmass derived from meteorological data
co2_column_weak_band_idp	Retrieval_Array	Float32	Molecules Meters^{-2}			CO2 vertical column density (from WCO2 band)
co2_column_weak_band_apriori_idp	Retrieval_Array	Float32	Molecules Meters^{-2}			*a priori CO2 vertical column density from ECMWF forecast*
co2_column_weak_band_uncert_idp	Retrieval_Array	Float32	Molecules Meters^{-2}			1-sigma error in the CO2 vertical column density (from WCO2 band)
co2_column_strong_band_idp	Retrieval_Array	Float32	Molecules Meters^{-2}			CO2 vertical column density (from SCO2 band)
co2_column_strong_band_apriori_idp	Retrieval_Array	Float32	Molecules Meters^{-2}			*a priori* CO2 vertical column density from ECMWF forecast
co2_column_strong_band_uncert_idp	Retrieval_Array	Float32	Molecules Meters^{-2}			1-sigma error in the CO2 vertical column density (from SCO2 band)
co2_weak_band_processing_flag_idp	Retrieval_Array	Int8		0	2	Indicator of whether the WCO2 analysis succeeded: 0 - 'Processing succeeded', 1 - 'Processing failed', 2 - 'Processing skipped', all other values undefined
co2_strong_band_processing_flag_idp	Retrieval_Array	Int8		0	2	Indicator of whether the SCO2 analysis succeeded: 0 - 'Processing succeeded', 1 - 'Processing failed', 2 - 'Processing skipped', all other values undefined
cloud_flag_idp	Retrieval_Array	Int8		-2	3	Cloud flag derived from IMAP-DOAS algorithm: -2 - 'Measurement unusable', -1 - 'Did not converge', 0 - "Definitely cloudy', 1 - 'Probably cloudy', 2 - 'Probably clear', 3 - 'Very clear', all other values undefined.
co2_ratio_idp	Retrieval_Array	Float32				Ratio of retrieved CO2 column (no scattering code) in WCO2 and SCO2 bands
h2o_ratio_idp	Retrieval_Array	Float32				Ratio of retrieved H2O column (no scattering code) in WCO2 and SCO2 bands
h2o_ratio_uncert_idp	Retrieval_Array	Float32				1-sigma error in the ratio of retrieved H2O column (no scattering code) in WCO2 and SCO2 bands
o2_ratio_idp	Retrieval_Array	Float32				Ratio of retrieved and ECMWF O2 column
fluorescence_qual_flag_idp	Retrieval_Array	UInt8				Indicator of the quality of the IMAP DOAS fluorescence retrieval for each sounding: 0 - good, 1 - bad
fluorescence_offset_relative_757nm_idp	Retrieval_Array	Float32				Fraction of continuum level radiance explained by an additive offset term in the 757nm spectral window (unitless). In the absence of instrumental errors, this will be only caused by fluorescence. Rotational Raman scattering should be negligible over typical vegetated surface and moderate solar zenith angles (<65 degrees).
fluorescence_offset_relative_771nm_idp	Retrieval_Array	Float32				Fraction of continuum level radiance explained by an additive offset term in the 771nm spectral window (unitless). In the absence of instrumental errors, this will be only caused by fluorescence. Rotational Raman scattering should be negligible over typical vegetated surface and moderate solar zenith angles (<65 degrees).
fluorescence_radiance_757nm_idp	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			Radiance generated by fluorescence at 757nm

fluorescence_radiance_757nm_uncert_idp	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			Standard deviation of the radiance generated by fluorescence at 757nm
fluorescence_radiance_771nm_idp	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			Radiance generated by fluorescence at 771nm
fluorescence_radiance_771nm_uncert_idp	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			Standard deviation of the radiance generated by fluorescence at 771nm
selection_priority	Retrieval_Array	Int8		0	20	Indicator of the likelihood of generating a good retrieval from the sounding: 0 = most likely, 20 = least likely
cloud_flag_abp	Retrieval_Array	Int8		0	2	Indicator of whether the sounding contained clouds: 0 - 'Classified clear', 1 - 'Processing failed', 2 - 'Not classified', all other values undefined
Group	**RetrievalResults**					
Group description	Results from L2 Full-physics retrievals					
Data Element	**Shape**	**Type**	**Units**	**Minimum value**	**Maximum value**	**Comments**
num_active_levels	Retrieval_Array	Int16				Number of levels in atmospheric model
surface_type	Retrieval_Array	String				Type of model used for the Earth's surface: 'Lambertian' or ' Coxmumk,Lambertian'
outcome_flag	Retrieval_Array	Int8				Indicator of retrieval results: 1 - 'Passed internal quality check', 2 - 'Failed internal quality check', 3 - 'Reached maximum allowed iterations', 4 - 'Reached maximum allowed divergences'
vector_pressure_levels_ecmwf	Retrieval_ECMWFLevel_Array	Float32	Pascals			Pressure altitude corresponding to each ECMWF atmospheric level
temperature_profile_ecmwf	Retrieval_ECMWFLevel_Array	Float32	Kelvins			ECMWF temperature profile interpolated to observation location, time
specific_humidity_profile_ecmwf	Retrieval_ECMWFLevel_Array	Float32	Kilograms Kilogram^{-1}			ECMWF specific humidity profile interpolated to observation location, time
surface_pressure_fph	Retrieval_Array	Float32	Pascals			Surface pressure retrieved by Full-physics algorithm
surface_pressure_apriori_fph	Retrieval_Array	Float32	Pascals			*a priori* surface pressure retrieved by Full-physics algorithm
surface_pressure_uncert_fph	Retrieval_Array	Float32	Pascals			Uncertainty in the surface pressure retrieved by the Full-physics algorithm
vector_pressure_levels	Retrieval_Level_Array	Float32	Pascals			Pressure altitude corresponding to each atmospheric level
vector_pressure_levels_apriori	Retrieval_Level_Array	Float32	Pascals			*a priori* pressure altitude corresponding to each atmospheric level
diverging_steps	Retrieval_Array	Int16				Number of iterations in which solution diverged
iterations	Retrieval_Array	Int16				Number of iterations
dof_co2_profile	Retrieval_Array	Float32				Degrees of freedom (XCO2 only)
dof_full_vector	Retrieval_Array	Float32				Degrees of freedom (Full state vector)
xco2	Retrieval_Array	Float32	Moles Mole^{-1}			Column-averaged CO_2 dry air mole fraction

xco2_apriori	Retrieval_Array	Float32	Moles Mole^{-1}			a priori of column-averaged CO2 dry air mole fraction
xco2_uncert	Retrieval_Array	Float32	Moles Mole^{-1}			Uncertainty in column averaged CO_2 dry air mole fraction
xco2_uncert_noise	Retrieval_Array	Float32	Moles Mole^{-1}			Variance of XCO2 due to noise
xco2_uncert_smooth	Retrieval_Array	Float32	Moles Mole^{-1}			Variance of XCO2 due to smoothing
xco2_uncert_interf	Retrieval_Array	Float32	Moles Mole^{-1}			Variance of XCO2 due to interference
co2_profile	Retrieval_Level_Array	Float32	Moles Mole^{-1}			Vertical profile of CO_2
co2_profile_apriori	Retrieval_Level_Array	Float32	Moles Mole^{-1}			Vertical a priori profile of CO2
co2_profile_uncert	Retrieval_Level_Array	Float32	Moles Mole^{-1}			Vertical profile of CO_2 uncertainty
xco2_pressure_weighting_function	Retrieval_Level_Array	Float32				Pressure weighting function used to form XCO2
xco2_avg_kernel	Retrieval_Level_Array	Float32				Column averaging kernel
xco2_avg_kernel_norm	Retrieval_Level_Array	Float32				Normalized column averaging kernel
co2_profile_averaging_kernel_matrix	Retrieval_Level_Level_Array	Float32				Averaging kernel for CO_2 profile
co2_profile_covariance_matrix	Retrieval_Level_Level_Array	Float32	Moles^{2} Mole^{-2}			Covariance matrix for CO_2 profile
wind_speed	Retrieval_Array	Float32	Meters Second^{-1}			Retrieved Cox-Munk wind speed
wind_speed_apriori	Retrieval_Array	Float32	Meters Second^{-1}			a priori of retrieved Cox-Munk wind speed
wind_speed_uncert	Retrieval_Array	Float32	Meters Second^{-1}			Uncertainty of retrieved Cox-Munk wind speed
h2o_scale_factor	Retrieval_Array	Float32				Retrieved scale factor for H_2O profile
h2o_scale_factor_apriori	Retrieval_Array	Float32				a priori of retrieved scale factor for H2O profile
h2o_scale_factor_uncert	Retrieval_Array	Float32				Uncertainty of retrieved scale factor for H_2O profile
temperature_offset_fph	Retrieval_Array	Float32	Kelvins			Retrieved offset of temperature profile
temperature_offset_apriori_fph	Retrieval_Array	Float32	Kelvins			a priori of retrieved offset of temperature profile
temperature_offset_uncert_fph	Retrieval_Array	Float32	Kelvins			Uncertainty of retrieved offset of temperature profile
fluorescence_at_reference	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			Retrieved fluorescence at 0.757 microns
fluorescence_at_reference_apriori	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			a priori of retrieved fluorescence at 0.757 microns
fluorescence_at_reference_uncert	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			Uncertainty of retrieved fluorescence at 0.757 microns

fluorescence_slope	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-2}			Retrieved fluorescence slope at 0.757 microns
fluorescence_slope_apriori	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-2}			a priori of retrieved fluorescence slope at 0.757 microns
fluorescence_slope_uncert	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-2}			Uncertainty of retrieved fluorescence slope at 0.757 microns
eof_1_scale_o2	Retrieval_Array	Float32				Retrieved scale factor of first empirical orthogonal residual function in ABO2 band
eof_1_scale_apriori_o2	Retrieval_Array	Float32				a priori of retrieved scale factor of first empirical orthogonal residual function in ABO2 band
eof_1_scale_uncert_o2	Retrieval_Array	Float32				Uncertainty of retrieved scale factor of first empirical orthogonal residual function in ABO2 band
eof_1_scale_weak_co2	Retrieval_Array	Float32				Retrieved scale factor of first empirical orthogonal residual function in WCO2 band
eof_1_scale_apriori_weak_co2	Retrieval_Array	Float32				a priori of retrieved scale factor of first empirical orthogonal residual function in WCO2 band
eof_1_scale_uncert_weak_co2	Retrieval_Array	Float32				Uncertainty of retrieved scale factor of first empirical orthogonal residual function in WCO2 band
eof_1_scale_strong_co2	Retrieval_Array	Float32				Retrieved scale factor of first empirical orthogonal residual function in SCO2 band
eof_1_scale_apriori_strong_co2	Retrieval_Array	Float32				a priori of retrieved scale factor of first empirical orthogonal residual function in SCO2 band
eof_1_scale_uncert_strong_co2	Retrieval_Array	Float32				Uncertainty of retrieved scale factor of first empirical orthogonal residual function in SCO2 band
eof_2_scale_o2	Retrieval_Array	Float32				Retrieved scale factor of second empirical orthogonal residual function in ABO2 band
eof_2_scale_apriori_o2	Retrieval_Array	Float32				a priori of retrieved scale factor of second empirical orthogonal residual function in ABO2 band
eof_2_scale_uncert_o2	Retrieval_Array	Float32				Uncertainty of retrieved scale factor of second empirical orthogonal residual function in ABO2 band
eof_2_scale_weak_co2	Retrieval_Array	Float32				Retrieved scale factor of second empirical orthogonal residual function in WCO2 band
eof_2_scale_apriori_weak_co2	Retrieval_Array	Float32				a priori of retrieved scale factor of second empirical orthogonal residual function in WCO2 band
eof_2_scale_uncert_weak_co2	Retrieval_Array	Float32				Uncertainty of retrieved scale factor of second empirical orthogonal residual function in WCO2 band
eof_2_scale_strong_co2	Retrieval_Array	Float32				Retrieved scale factor of second empirical orthogonal residual function in SCO2 band
eof_2_scale_apriori_strong_co2	Retrieval_Array	Float32				a priori of retrieved scale factor of second empirical orthogonal residual function in SCO2 band
eof_2_scale_uncert_strong_co2	Retrieval_Array	Float32				Uncertainty of retrieved scale factor of second empirical orthogonal residual function in SCO2 band
eof_3_scale_o2	Retrieval_Array	Float32				Retrieved scale factor of third empirical orthogonal residual function in ABO2 band
eof_3_scale_apriori_o2	Retrieval_Array	Float32				a priori of retrieved scale factor of third empirical orthogonal residual function in ABO2 band

eof_3_scale_uncert_o2	Retrieval_Array	Float32				Uncertainty of retrieved scale factor of third empirical orthogonal residual function in ABO2 band
eof_3_scale_weak_co2	Retrieval_Array	Float32				Retrieved scale factor of third empirical orthogonal residual function in WCO2 band
eof_3_scale_apriori_weak_co2	Retrieval_Array	Float32				a priori of retrieved scale factor of third empirical orthogonal residual function in WCO2 band
eof_3_scale_uncert_weak_co2	Retrieval_Array	Float32				Uncertainty of retrieved scale factor of third empirical orthogonal residual function in WCO2 band
eof_3_scale_strong_co2	Retrieval_Array	Float32				Retrieved scale factor of third empirical orthogonal residual function in SCO2 band
eof_3_scale_apriori_strong_co2	Retrieval_Array	Float32				a priori of retrieved scale factor of third empirical orthogonal residual function in SCO2 band
eof_3_scale_uncert_strong_co2	Retrieval_Array	Float32				Uncertainty of retrieved scale factor of third empirical orthogonal residual function in SCO2 band
co2_vertical_gradient_delta	Retrieval_Array	Float32	Moles Mole^{-1}			The difference between the retrieved value of the vertical gradient in the CO2 profile and its *a priori*
retrieved_dry_air_column_layer_thickness	Retrieval_Layer_Array	Float32	Molecules Meters^{-2}			Retrieved vertical column of dry air per atmospheric layer
retrieved_wet_air_column_layer_thickness	Retrieval_Layer_Array	Float32	Molecules Meters^{-2}			Retrieved vertical column of wet air per atmospheric layer
retrieved_h2o_column_layer_thickness	Retrieval_Layer_Array	Float32	Molecules Meters^{-2}			Retrieved vertical column of H_2O per atmospheric layer
apriori_o2_column	Retrieval_Array	Float32	Molecules Meters^{-2}			a priori vertical column of O2
retrieved_co2_column	Retrieval_Array	Float32	Molecules Meters^{-2}			Retrieved vertical column of CO_2
retrieved_h2o_column	Retrieval_Array	Float32	Molecules Meters^{-2}			Retrieved vertical column of H_2O
retrieved_o2_column	Retrieval_Array	Float32	Molecules Meters^{-2}			Retrieved vertical column of O_2
last_step_levenberg_marquardt_parameter	Retrieval_Array	Float32				Levenberg Marquardt parameter corresponding to last iteration
Group	**AlbedoResults**					
Group description	Albedo output from L2 Full-physics retrievals					
Data Element	**Shape**	**Type**	**Units**	**Minimum value**	**Maximum value**	**Comments**
albedo_o2_fph	Retrieval_Array	Float32				Retrieved Lambertian component of albedo at 0.77 microns
albedo_weak_co2_fph	Retrieval_Array	Float32				Retrieved Lambertian component of albedo at 1.615 microns
albedo_strong_co2_fph	Retrieval_Array	Float32				Retrieved Lambertian component of albedo at 2.06 microns
albedo_apriori_o2_fph	Retrieval_Array	Float32				a priori of retrieved Lambertian component of albedo at 0.77 microns
albedo_apriori_weak_co2_fph	Retrieval_Array	Float32				a priori of retrieved Lambertian component of albedo at 1.615 microns
albedo_apriori_strong_co2_fph	Retrieval_Array	Float32				a priori of retrieved Lambertian component of albedo at 2.06 microns

albedo_uncert_o2_fph	Retrieval_Array	Float32				Uncertainty of retrieved Lambertian component of albedo 0.77 microns
albedo_uncert_weak_co2_fph	Retrieval_Array	Float32				Uncertainty of retrieved Lambertian componet of albedo at 1.615 microns
albedo_uncert_strong_co2_fph	Retrieval_Array	Float32				Uncertainty of retrieved Lambertian component of albedo at 2.06 microns
albedo_slope_o2	Retrieval_Array	Float32	Centimeters			Retrieved spectral dependence of Lambertian component of albedo within ABO2 band
albedo_slope_weak_co2	Retrieval_Array	Float32	Centimeters			Retrieved spectral dependence of Lambertian component of albedo within WCO2 band
albedo_slope_strong_co2	Retrieval_Array	Float32	Centimeters			Retrieved spectral dependence of Lambertian component of albedo within SCO2 band
albedo_slope_apriori_o2	Retrieval_Array	Float32	Centimeters			a priori of retrieved spectral dependence of Lambertian component of albedo within ABO2 band
albedo_slope_apriori_weak_co2	Retrieval_Array	Float32	Centimeters			a priori of retrieved spectral dependence of Lambertian component of albedo within WCO2 band
albedo_slope_apriori_strong_co2	Retrieval_Array	Float32	Centimeters			a priori of spectral dependence of Lambertian component of albedo within SCO2 band
albedo_slope_uncert_o2	Retrieval_Array	Float32	Centimeters			Uncertainty of retrieved spectral dependence of Lambertian component of albedo within ABO2 band
albedo_slope_uncert_weak_co2	Retrieval_Array	Float32	Centimeters			Uncertainty of retrieved spectral dependence of Lambertian component of albedo within WCO2 band
albedo_slope_uncert_strong_co2	Retrieval_Array	Float32	Centimeters			Uncertainty of spectral dependence of Lambertian component of albedo within SCO2 band
Group	**DispersionResults**					
Group description	Dispersion output from L2 Full-physics retrievals					
Data Element	**Shape**	**Type**	**Units**	**Minimum value**	**Maximum value**	**Comments**
dispersion_offset_o2	Retrieval_Array	Float64	Microns			Retrieved dispersion offset term in ABO2 band
dispersion_offset_weak_co2	Retrieval_Array	Float64	Microns			Retrieved dispersion offset term in WCO2 band
dispersion_offset_strong_co2	Retrieval_Array	Float64	Microns			Retrieved dispersion offset term in SCO2 band
dispersion_offset_apriori_o2	Retrieval_Array	Float64	Microns			a priori of retrieved dispersion offset term in ABO2 band
dispersion_offset_apriori_weak_co2	Retrieval_Array	Float64	Microns			a priori of retrieved dispersion offset term in WCO2 band
dispersion_offset_apriori_strong_co2	Retrieval_Array	Float64	Microns			a priori of retrieved dispersion offset term in SCO2 band
dispersion_offset_uncert_o2	Retrieval_Array	Float32	Microns			Uncertainty of retrieved dispersion offset term in ABO2 band
dispersion_offset_uncert_weak_co2	Retrieval_Array	Float32	Microns			Uncertainty of retrieved dispersion offset term in WCO2 band
dispersion_offset_uncert_strong_co2	Retrieval_Array	Float32	Microns			Uncertainty of retrieved dispersion offset term in SCO2 band
dispersion_spacing_o2	Retrieval_Array	Float32	Microns			Retrieved dispersion spacing in ABO2 band
dispersion_spacing_weak_co2	Retrieval_Array	Float32	Microns			Retrieved dispersion spacing in WCO2 band
dispersion_spacing_strong_co2	Retrieval_Array	Float32	Microns			Retrieved dispersion spacing in SCO2 band

dispersion_spacing_apriori_o2	Retrieval_Array	Float32	Microns			a priori of retrieved dispersion spacing in ABO2 band
dispersion_spacing_apriori_weak_co2	Retrieval_Array	Float32	Microns			a priori of retrieved dispersion spacing in WCO2 band
dispersion_spacing_apriori_strong_co2	Retrieval_Array	Float32	Microns			a priori of retrieved dispersion spacing in SCO2 band
dispersion_spacing_uncert_o2	Retrieval_Array	Float32	Microns			Uncertainty of retrieved dispersion spacing in ABO2 band
dispersion_spacing_uncert_weak_co2	Retrieval_Array	Float32	Microns			Uncertainty of retrieved dispersion spacing in WCO2 band
dispersion_spacing_uncert_strong_co2	Retrieval_Array	Float32	Microns			Uncertainty of retrieved dispersion spacing in SCO2 band
Group	**AerosolResults**					
Group description						
Data Element	**Shape**	**Type**	**Units**	**Minimum value**	**Maximum value**	**Comments**
aerosol_1_gaussian_log_param	Retrieval_AerosolGaussianLogParam_Array	Float32				Retrieved gaussian log parameters for aerosol type 1 [total log aod, center pressure/surf-pressure, pressure sigma/surf-pressure]
aerosol_1_gaussian_log_param_apriori	Retrieval_AerosolGaussianLogParam_Array	Float32				a priori of retrieved gaussian log parameters for aerosol type 1
aerosol_1_gaussian_log_param_uncert	Retrieval_AerosolGaussianLogParam_Array	Float32				Uncertainty of retrieved gaussian log parameters for aerosol type 1
aerosol_2_gaussian_log_param	Retrieval_AerosolGaussianLogParam_Array	Float32				Retrieved gaussian log parameters of aerosol type 2 [total log aod, center pressure/surf-pressure, pressure sigma/surf-pressure]
aerosol_2_gaussian_log_param_apriori	Retrieval_AerosolGaussianLogParam_Array	Float32				a priori of retrieved gaussian log parameters for aerosol type 2
aerosol_2_gaussian_log_param_uncert	Retrieval_AerosolGaussianLogParam_Array	Float32				Uncertainty of retrieved gaussian log parameters for aerosol type 2
aerosol_3_gaussian_log_param	Retrieval_AerosolGaussianLogParam_Array	Float32				Retrieved gaussian log parameters for aerosol type 3 [total log aod, center pressure/surf-pressure, pressure sigma/surf-pressure]
aerosol_3_gaussian_log_param_apriori	Retrieval_AerosolGaussianLogParam_Array	Float32				a priori of retrieved gaussian log parameters for aerosol type 3
aerosol_3_gaussian_log_param_uncert	Retrieval_AerosolGaussianLogParam_Array	Float32				Uncertainty of retrieved gaussian log parameters of aerosol type 3
aerosol_4_gaussian_log_param	Retrieval_AerosolGaussianLogParam_Array	Float32				Retrieved gaussian log parameters for aerosol type 4 [total log aod, center pressure/surf-pressure, pressure sigma/surf-pressure]
aerosol_4_gaussian_log_param_apriori	Retrieval_AerosolGaussianLogParam_Array	Float32				a priori of retrieved gaussian log parameters for aerosol type 4
aerosol_4_gaussian_log_param_uncert	Retrieval_AerosolGaussianLogParam_Array	Float32				Uncertainty of retrieved gaussian log parameters for aerosol type 4
aerosol_1_aod	Retrieval_Array	Float32				Retrieved total column-integrated aerosol optical depth for aerosol type 1
aerosol_1_aod_low	Retrieval_Array	Float32				Retrieved column-integrated aerosol optical depth of aerosol type 1 for pressure levels greater than 80000 Pa

aerosol_1_aod_mid	Retrieval_Array	Float32				Retrieved column-integrated aerosol optical depth of aerosol type 1 for pressure levels between 50,000 and 80,000 Pa
aerosol_1_aod_high	Retrieval_Array	Float32				Retrieved column-integrated aerosol optical depth of aerosol type 1 for pressure levels less than 50,000 Pa
aerosol_2_aod	Retrieval_Array	Float32				Retrieved total column-integrated aerosol optical depth for aerosol type 2
aerosol_2_aod_low	Retrieval_Array	Float32				Retrieved column-integrated aerosol optical depth of aerosol type 2 for pressure levels greater than 80,000 Pa
aerosol_2_aod_mid	Retrieval_Array	Float32				Retrieved column-integrated aerosol optical depth of aerosol type 2 for pressure levels between 50,000 and 80,000 Pa
aerosol_2_aod_high	Retrieval_Array	Float32				Retrieved column-integrated aerosol optical depth of aerosol type 2 for pressure levels less than 50,000 Pa
aerosol_3_aod	Retrieval_Array	Float32				Retrieved total column-integrated aerosol optical depth for aerosol type 3
aerosol_3_aod_low	Retrieval_Array	Float32				Retrieved column-integrated aerosol optical depth of aerosol type 3 for pressure levels greater than 80,000 Pa
aerosol_3_aod_mid	Retrieval_Array	Float32				Retrieved column-integrated aerosol optical depth of aerosol type 3 for pressure levels between 50,000 and 80,000 Pa
aerosol_3_aod_high	Retrieval_Array	Float32				Retrieved column-integrated aerosol optical depth of aerosol type 3 for pressure levels less than 50,000 Pa
aerosol_4_aod	Retrieval_Array	Float32				Retrieved total column-integrated aerosol optical depth for aerosol type 4
aerosol_4_aod_low	Retrieval_Array	Float32				Retrieved column-integrated aerosol optical depth of aerosol type 4 for pressure levels greater than 80,000 Pa
aerosol_4_aod_mid	Retrieval_Array	Float32				Retrieved column-integrated aerosol optical depth of aerosol type 4 for pressure levels between 50,000 and 80,000 Pa
aerosol_4_aod_high	Retrieval_Array	Float32				Retrieved column-integrated aerosol optical depth of aerosol type 4 for pressure levels less than 50,000 Pa
aerosol_types	Retrieval_AerosolType_Array	String				Retrieved aerosol type
aerosol_total_aod	Retrieval_Array	Float32				Retrieved total column-integrated aerosol optical depth for all aerosol types
aerosol_total_aod_low	Retrieval_Array	Float32				Retrieved column-integrated aerosol optical depth for all aerosol types for pressure levels greater than 80,000 Pa
aerosol_total_aod_mid	Retrieval_Array	Float32				Retrieved column-integrated aerosol optical depth for all aerosol types for pressure levels between 50,000 and 80,000 Pa
aerosol_total_aod_high	Retrieval_Array	Float32				Retrieved column-integrated aerosol optical depth for all aerosol types for pressure levels less than 50,000 Pa
Group	**SpectralParameters**					
Group description	Statistics on the spectral fit					
Data Element	**Shape**	**Type**	**Units**	**Minimum value**	**Maximum value**	**Comments**
residual_mean_square_o2	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			Mean of the squares of the residuals for the ABO2 band

residual_mean_square_weak_co2	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			Mean of the squares of the residuals for the WCO2 band
residual_mean_square_strong_co2	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			Mean of the squares of the residuals for the SCO2 band
signal_o2_fph	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			Aggregate signal in the ABO2 band
signal_weak_co2_fph	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			Aggregate signal in the WCO2 band
signal_strong_co2_fph	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			Aggregate signal in the SCO2 band
noise_o2_fph	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			Aggregate noise in the ABO2 band
noise_weak_co2_fph	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			Aggregate noise in the WCO2 band
noise_strong_co2_fph	Retrieval_Array	Float32	Ph sec^{-1} m^{-2} sr^{-1} um^{-1}			Aggregate noise in the SCO2 band
relative_residual_mean_square_o2	Retrieval_Array	Float32				Mean square of the residuals divided by the signal for the ABO2 band
relative_residual_mean_square_weak_co2	Retrieval_Array	Float32				Mean square of the residuals divided by the signal for the WCO2 band
relative_residual_mean_square_strong_co2	Retrieval_Array	Float32				Mean square of the residuals divided by the signal for the SCO2 band
reduced_chi_squared_o2_fph	Retrieval_Array	Float32				Reduced chi squared of spectral fit of the ABO2 band
reduced_chi_squared_weak_co2_fph	Retrieval_Array	Float32				Reduced chi squared of spectral fit of the WCO2 band
reduced_chi_squared_strong_co2_fph	Retrieval_Array	Float32				Reduced chi squared of spectral fit of the SCO2 band

Product Quality Flags

co2_weak_band_processing_flag_idp co2_strong_band_processing_flag_idp		cloud_flag		fluorescence_qual_flag		outcome_flag	
Value	**Meaning**	**Value**	**Meaning**	**Value**	**Meaning**	**Value**	**Meaning**
0	Processing succeeded	-2	Measurements unusable	0	Good	-1	Packaging failure
1	Processing failed	-1	Did not converge	1	Bad	-2	Bad Fill
2	Processing skipped	0	Definitely cloudy			1	Passed internal quality check
		1	Probably cloudy			2	Failed internal quality check
		2	Probably clear			3	Reached maximum allowed iterations
		3	Very clear			4	Reached maximum allowed divergences

packaging_qual_flag	
Value	
0	Spare
1	Spare
2	1 = Sounding excluded during sounding selection
3	1 = Packaging skipped due to missing L2 Full-physics Algorithm output
4	1 = Packaging skipped due to failed validation of L2 Full-physics Algorithm output
5	1 = Packaging failed due to error while reading L2 Full-physics Algorithm output
6	Spare
7	1 = Packaging failed due to miscellaneous error in PGE

sounding_qual_flag	
Bit	**Meaning**
0	0 = The PGE successfully calculated the sounding position.
1	0 = Reported sounding time valid
2	0 = Ephemeris data associated with sounding invalid
3	0 = Attitude data associated with sounding invalid
4	1 = Aperture blocked by Cal Door while in Science mode
5-15	Spare
16	0 = The PGE successfully calculated the ABO2 sample radiances for the current sounding.
17	0 = The PGE successfully calculated the WCO2 sample radiances for the current sounding.

sounding_qual_flag	
18	0 = The PGE successfully calculated the SCO2 sample radiances for the current sounding.
19	0 = Frame-level engineering data valid
20	0 = ABO2 engineering data valid
21	0 = WCO2 engineering data valid
22	0 = SCO2 engineering data valid
23	0 = ABO2 summed offset and multiplier valid
24	0 = WCO2 summed offset and multiplier valid
25	0 = SCO2 summed offset and multiplier valid
26	0 = ABO2 footprint position valid
27	0 = WCO2 footprint position valid
28	0 = SCO2 footprint position valid
29	0 = Radiance for all colors is less than or equal to measureable_signal_max_observed for ABO2
30	0 = Radiance for all colors is less than or equal to measureable_signal_max_observed for WCO2
31	0 = Radiance for all colors is less than or equal to measureable_signal_max_observed for SCO2
32-63	Spare

OCO-2 Standard Metadata

Group	Metadata					
Group description	This table describes the metadata contained in all OCO-2 HDF products. These metadata fields appear in the Metadata group in each of these products. Each product may also contain product-specific fields in that group.					
Data Element	**Shape**	**Type**	**Units**	**Minimum value**	**Maximum value**	**Comments**
AncillaryDataDescriptors	AncFile_Array	String				The file names of the ancillary data files that were used to generate this product (ancillary data sets include all input files except for the primary input files)
BuildId	Scalar	String				The ID of build in which included the software that created this product
CollectionLabel	Scalar	String				Label of the data collection containing this product
DataFormatType	Scalar	String				'NCSA HDF' - A character string that describes the internal format of the data product.
GapStartTime	Gap_Array	String				The timestamp after which a nonexistent, unnecessary, spurious, questionable, or erroneous data segment begins. Set to 1993-01-01T00:00:00.000Z if no bad segment exists.
GapStopTime	Gap_Array	String				The timestamp before which a nonexistent, unnecessary, spurious, questionable, or erroneous data segment ends. Set to 1993-01-01T00:00:00.000Z if no bad segment exists.
GranulePointer	Scalar	String				The filename of this product
HDFVersionId	Scalar	String				'5.x' - A character string that identifies the version of the HDF (Hierarchical Data Format) software that was used to generate this data file
InputPointer	InputPtr_Array	String				A pointer to one or more data granules that provide the major input that was used to generate this product.
InstrumentShortName	Scalar	String				'OCO-2' - The name of the instrument that collected the telemetry data
LongName	Scalar	String				A complete descriptive name for the data type of this product
PlatformLongName	Scalar	String				'Orbiting Carbon Observatory 2'
PlatformShortName	Scalar	String				'OCO-2'
PlatformType	Scalar	String				'spacecraft' - The type of platform associated with the instrument which acquires the accompanying data
ProcessingLevel	Scalar	String				Indicates data level (Level 0, Level 1A, Level 1B, Level 2) in this product
ProducerAgency	Scalar	String				'NASA' - Identification of the agency that provides the project funding
ProducerInstitution	Scalar	String				'JPL' - Identification of the institution that provides project management.
ProductionDateTime	Scalar	String				The date and time at which the product was created (yyyy-mm-ddThh:mm:ss.mmmZ)
ProductionLocation	Scalar	String				Facility in which this file was produced, typically: 'Operations Pipeline', 'Operations Pipeline 2', 'Science Computing Facility', 'Test Pipeline', Test Pipeline 2'
ProductionLocationCode	Scalar	String				One-letter code indicating the ProductionLocation, typically: ' ' - Operations Pipelines (1) or 2, 's' - Science Computing Facility, 't' - Test Pipelines (1) or 2

ProjectId	Scalar	String				'OCO-2' - The project identification string
QAGranulePointer	Scalar	String				A pointer to the quality assessment product that was generated with this product
RangeBeginningDate	Scalar	String				The date on which the earliest data contained in the product were acquired (yyyy-mm-dd)
RangeBeginningTime	Scalar	String				The time at which the earliest data contained in the product were acquired (hh:mm:ss.mmmZ)
RangeEndingDate	Scalar	String				The date on which the latest data contained in the product were acquired (yyyy-mm-dd)
RangeEndingTime	Scalar	String				The time at which the latest data contained in the product were acquired (hh:mm:ss.mmmZ)
ShortName	Scalar	String				The short name identifying the data type of this product
SISName	Scalar	String				The name of the document describing the contents of the product
SISVersion	Scalar	String				The version of the document describing the contents of the product
SizeMBECSDataGranule	Scalar	Float32	Megabytes			The size of this data granule in Megabytes
StartOrbitNumber	Scalar	Int32		1	99999	The first orbit on which data contained in the product were acquired
StartPathNumber	Scalar	Int32		1	233	The first WRS path on which data contained in the product was collected
StopOrbitNumber	Scalar	Int32		1	99999	The last orbit on which data contained in the product were acquired
StopPathNumber	Scalar	Int32		1	233	The last WRS path on which data contained in the product was collected

6 Appendix 1: Shape Descriptions

The shape name of a data element is a descriptive label that describes the rank and dimensions of that element.

Rules for creating shapes:

1. Shape names do not include any context information, such as what mode the instrument is in when it takes data with that shape. Any context information needed to distinguish between similarly named dimensions is appended as a label, just before the "_Array" suffix.
2. Any "temporal" dimension, e.g. Frame, is always outermost.
3. If Frame and Sounding are both present, they occur in direct sequence, i.e. Frame_Sounding_.
4. Shapes that include Frame, Sounding, and Spectrum cannot have any additional dimensions.
5. Spectrum precedes all other physical instrument dimensions, except when this rule contradicts any of the above rules.
6. If Spectrum and Sounding are present in the absence of Frame, they occur in direct sequence, i.e., Spectrum_Sounding.
7. Color comes after SinglePixel.
8. SinglePixel comes after Slice.

Shape	Rank	Max dimension sizes (Units)	Dimensions
AncFile_Array	1	20 (Number of ancillary input files)	AncFile
Frame_Sounding_Array	2	10512 (Frames) x 8 (Soundings)	Frame, Sounding
Gap_Array	1	10 (Number of gaps)	Gap
InputPtr_Array	1	20 (Number of primary input files)	InputFile
L2FullPhysicsInputPtr_Array	1	20 (Number of primary input files)	L2FullPhysicsInputPtr
OrbitParamPtr_Array	1	16 (Attitude and ephemeris files)	OrbitFile
Retrieval_AerosolGaussianLogParam_Array	2	37008 (Retrievals) x 3 (Parameters)	Retrieval, AerosolGaussianLogParam
Retrieval_AerosolType_Array	2	37008 (Retrievals) x 4 (Types)	Retrieval, AerosolType
Retrieval_AlbedoWavelength_Array	2	37008 (Retrievals) x 2 (Wavelengths)	Retrieval, AlbedoWavelength
Retrieval_Array	1	37008 (Retrievals)	Retrieval
Retrieval_ECMWFLevel_Array	2	37008 (Retrievals) x 137 (Atmospheric Levels)	Retrieval, ECMWFLevel
Retrieval_Layer_Array	2	37008 (Retrievals) x 20 (Layers)	Retrieval, Layer
Retrieval_Level_Array	2	37008 (Retrievals) x 12 (Atmospheric levels)	Retrieval, Level
Retrieval_Level_Level_Array	3	37008 (Retrievals) x 12 (Atmospheric levels) x 12 (Atmospheric levels)	Retrieval, Level, Level
Retrieval_RetrievalColor_Array	2	37008 (Retrievals) x 3048 (Spectral Pixels)	Retrieval, RetrievalColor
Retrieval_Spectrum_Array	2	37008 (Retrievals) x 3 (Spectrometers)	Retrieval, Spectrum
Retrieval_Spectrum_Vertex_Array	4	37008 (Retrievals) x 3 (Spectrometers) x 4 (Vertices)	Retrieval, Spectrum, Vertex
SoundingPosition_Array	1	8 (Maximum number of footprints)	SoundingPosition
Spectrum_Array	1	3 (Spectrometers)	Spectrum

7 Appendix 2: Acronyms

AOD	Aerosol Optical Depth
APID	Application Process Identifier
ASCII	American Standard Code for Information Interchange
ASD	Algorithm Specification Document
ATBD	Algorithm Theoretical Basis Document
CO_2	Carbon Dioxide
DAAC	Distributed Active Archive Center
DOORS	Dynamic Object Oriented Requirements
ECHO	Earth observing system Clearing HOuse - The NASA-developed spatial and temporal metadata registry
ECMWF	European Center for Medium-range Weather Forecast
EDOS	EOS Data and Operations System
EOS	Earth Observing System
GES DISC	Goddard Earth Sciences Data and Information Services Center
HDF	Hierarchical Data Format
HECC	High-end Computing Capability
ICD	Interface Control Document
IMAP-DOAS	Iterative Maximum *A Posteriori* Differential Optical Absorption Spectroscopy
IOC	In-Orbit Checkout
ITAR	International Traffic in Arms Regulations
MOS	Mission Operations System
MOU	Memorandum of Understanding
NAS	NASA Advanced Supercomputing
NASA	National Aeronautics and Space Administration
O_2	Oxygen
OCO	Orbiting Carbon Observatory
PGE	Product Generation Executable
SCF	Science Computing Facility
SDOS	Science Data Operations System
SIS	Software Interface Specification
SP4A	Simple, Scalable Script-based Science Processor Archive
TBD	To Be Determined
TCCON	Total Carbon Column Observing Network
UTC	Coordinated Universal Time
X_{CO2}	Column-averaged dry air mole fraction of atmospheric CO_2