Compact Ocean Wind Vector Radiometer (COWVR) Project

Environmental Data Record Data Product Description Document

B8.0

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CHANGE LOG

DATE	SECTIONS CHANGED	REASON FOR CHANGE	REVISION
4/19/17	ALL		
4/15/21	Many	Release 6 updates	
11/15/21	Many	Release 7 updates	B7
9/20/22	4.1, 4.3, 4.5-4.7, 5.3, 5.8, 6.2	Release 7.3.5 updates	B7.3.5
02/22/2023		Release 7.4.0, and separation into EDR only DPDD	Initial Release
08/22/2023	4.1, 4.2, 4.3, 4.4, 4.5, 4.7, 4.8, 4.9, 4.10, 4.11	Release 8.0 COWVR EDR (L2) products	

Table of Contents

1 Introduction

1.1. Purpose and Scope

This Compact Ocean Wind Vector Radiometer (COWVR) Data Product Description Document (DPDD) describes the contents of the COWVR mission data products.

1.2. Mission Description

The United States Space Force (USSF), Space Systems Command, Development Corps for Innovation and Prototyping (SSC/DCI) is flying the JPL-provided Compact Ocean Wind Vector Radiometer (COWVR) and Temporal Experiment for Storms and Tropical Systems (TEMPEST) instruments as part of the Space Test Program - Houston 8 (STP-H8) technology demonstration mission.

The primary objective of STP-H8 Mission is to characterize and demonstrate the end-to-end COWVR performance relative to the Department of Defense (DoD) legacy microwave sensor WindSat on-orbit performance and mission requirements. A successful COWVR mission will demonstrate a lower-cost sensor architecture for providing imaging passive microwave data, including ocean surface vector wind (OSVW) products for DoD. The TEMPEST instrument, was included as an STP-H8 mission enhancement, in support of the SSC/DCI objective of Tropical Cyclone Intensity (TCI) tracking. The STP-H8 payload module with the COWVR and TEMPEST instruments was launched on December 21, 2021 and was installed on the International Space Station (ISS), Japanese Experiment Module – Exposed Facility (JEM-EF) on January 7, 2022. Both COWVR and TEMPEST are currently operating nominally on-orbit.

1.3. Instrument Description

The Compact Ocean Wind Vector Radiometer (COWVR) sensor is a fully polarimetric, conically imaging microwave radiometer, operating at 18.7 GHz, 23.8 GHz, and 34.5 GHz, for measuring ocean surface vector winds (OSVW). The novel COWVR design features include:

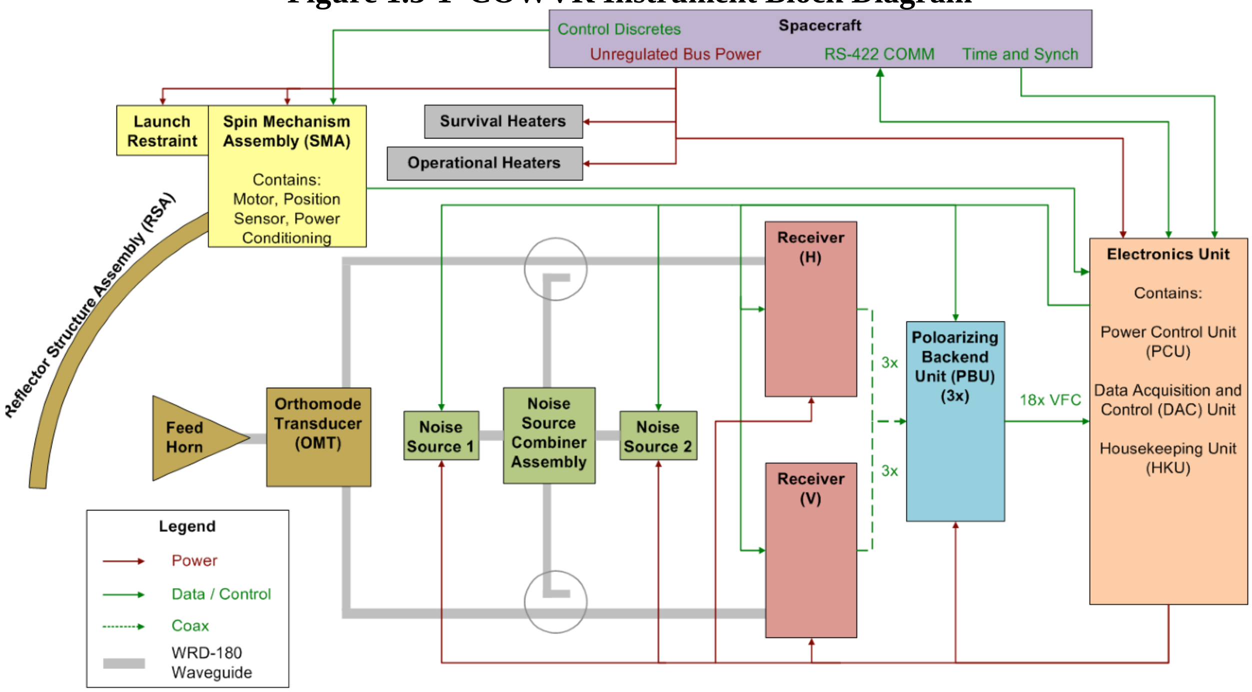
- the use of a single multi-frequency feed horn enabling a simple antenna rotating about the feed axis (as opposed to having to spin the entire radiometer system)
- internal polarimetric calibration sources which eliminate the need for an external warm load and cold sky reflector simplifying the mechanical design
- a compact MMIC receiver implementation, lowering the system mass, power and volume

Figure 1.3-1 shows the instrument block diagram and components. Subsystems are defined as follows:

- The Electronics Unit (EU) contains three sub-elements. The Power Control Unit (PCU) provides power to all secondary power from the unregulated spacecraft bus to the instrument electronics, excluding the mechanism (motor, motor controller, and position sensor). The Data Acquisition and Control (DAC) unit communicates with the spacecraft, supplies all RF control signals, and receives all RF and housekeeping data. The Housekeeping Unit (HKU) reads all engineering voltages and temperatures and supplies them to the DAC.

- The RF Subsystem consists of the feed horn, orthomode transducer (OMT), waveguides, Noise Source Combiner Assembly (NSCA), two noise sources, two receivers, and the Polarimetric Backend Unit (PBU).
- The Mechanical and Thermal Subsystem (MTS) consists of the launch restraint, thermal control system, reflector structure assembly (RSA), Spin Mechanism Assembly (SMA), and all structures to support the various instrument sub-element chassis. The SMA includes the motor, motor controller, position sensor, and mechanism power conditioning board.

Figure 1.3-1 COWVR Instrument Block Diagram



1.4. Document Structure

1.4.1. Applicable Documents

Figure 1.4-1 illustrates the COWVR requirements flow. This document is consistent and responsive to the requirements in the following requirements:

- COWVR Data Product Requirements Document (DPRD) (D-80123)

1.4.2. Acronyms

ACS	Attitude and Control System
AMR	Advanced Microwave Radiometer
ATBD	Algorithm Theoretical Basis Document

APC	Antenna Pattern Correction
CALNS	Calibration Noise Source
CFOV	Composite Field of View (weighted average of IFOV main beam measurements calculated on the ground by re-sampling algorithm)
CM	Center of Mass
CSEQ	Configuration Sequence
CSEQ	Configuration Sequence
DAC	Data Acquisition
EPBR	Electronic Polarization Basis Rotation
EPOI	Effective Product of Inertia
ES	Electronics Subsystem
II&T	Instrument Integration and Test
MSEQ	Measurement Sequence
IFOV	Instantaneous Field of View (measured main beam)
MIC	Microwave Integrated Circuit
MMIC	Monolithic Microwave Integrated Circuit
OSTM	Ocean Surface Topology Mission
OSVW	Ocean Surface Vector Winds
OMT	Ortho-mode Transducer
PBU	Polarimetric Backend Unit
PCU	Power Converter Unit
PL	Payload
PPS	Pulse Per Second
RFI	Radio Frequency Interference
RSS	Root Sum (of) Squares
SMDE	Spin Mechanism Drive Electronics
TB	Brightness Temperature
VFC	Voltage to Frequency Converter
VNA	Vector Network Analyzer

2 Overview of COWVR

Conically imaging passive microwave radiometer systems such as the Special Sensor Microwave Imager (SSM/I, SSMIS), the Advanced Microwave Scanning Radiometer (AMSR-E, AMSR-2) and WindSat, have been providing critical environmental data for over 30 years. But over this time, the overall sensor design has remained largely unchanged. These conical sensors have three basic attributes; (1) A large, massive spun portion containing the radiometer and electronics system; (2) A de-spun external un-polarized warm target and cold sky reflector and; (3) a large feedhorn array and individual receivers for each frequency and polarization. These design attributes drive the instrument mechanical complexity, spacecraft accommodation (e.g. momentum compensation) and instrument cost. For example, the WindSat needed to offset 189 Nms of spun momentum from the sensor (Koss and Woolaway, 2006). The sensors that were in development for NPOESS (CMIS and later MIS) were each expected to exceed 300 kg, 300 W and cost more than $100M (Chauhan, 2003). It is clear that a simplified design solution is needed to reduce the sensor mass, power, cost and accommodation, yet maintain the legacy performance.

The COWVR instrument uses an entirely different design to eliminate the instrument mechanical complexity that drives mass, power and cost. The enabling design features include (1) the use of a single multi-frequency feed horn permitting a simple antenna rotating about the feed axis, as opposed to having to spin the entire radiometer system and pass signals through the spin assembly; (2) internal calibration sources which enable fully polarimetric calibration and eliminate the need for an external warm load and cold sky reflector simplifying the mechanical design and enabling a complete 360^o scan and; (3) a compact highly integrated MMIC polarimetric combining receiver implementation, lowering the system mass and power which in turn makes the system well suited for deployment on smaller class, lower cost satellites.

An illustration of the COWVR instrument design is shown in Figure 2-1. The instrument includes a single stationary multi-frequency feed horn that illuminates rotating reflector generating a 360^o un-blocked conical scan. The reflector rotates at 30 RPM and provides a spatial resolution <35km and a swath width of 1012 km from the mission orbit altitude of 450km. After the feed, an orthomode transducer is used to separate the signal into two linear orthogonal components which are then fed via waveguide into MMIC multi-frequency receivers to amplify and filter the signals. The output from the receivers is input to a hybrid combining polarimetric backend unit which performs the analog in-phase and quadrature phase cross-correlation of the two signals to produce the +45, -45 and left and right circular polarized outputs.

The instrument is calibrated using PIN-diode switches internal to the receivers and a correlated noise source. The switches are used to toggle each receiver between an ambient reference load and the antenna. The correlated noise source is capable of generating known polarized signals by injecting correlated noise with a defined phase offset between the two receiver chains.

Because the feedhorn is fixed, the instrument polarization is fixed to the instrument frame and rotates relative to the Earth polarization basis. Because the instrument measures the full stokes vector, which completely describes the polarization state of the scene, a simple geometric transform is used in ground processing to rotate the polarization from the fixed instrument frame to the Earth frame. This technique has been previously used in groundbased and airborne radiometer systems and is commonly referred to as Electronic Polarization Basis Rotation (EPBR) (Gasiewski et al., 1992; Lahtinen et al,. 2003). This actually presents a calibration advantage which is discussed further in the COWVR calibration plan.

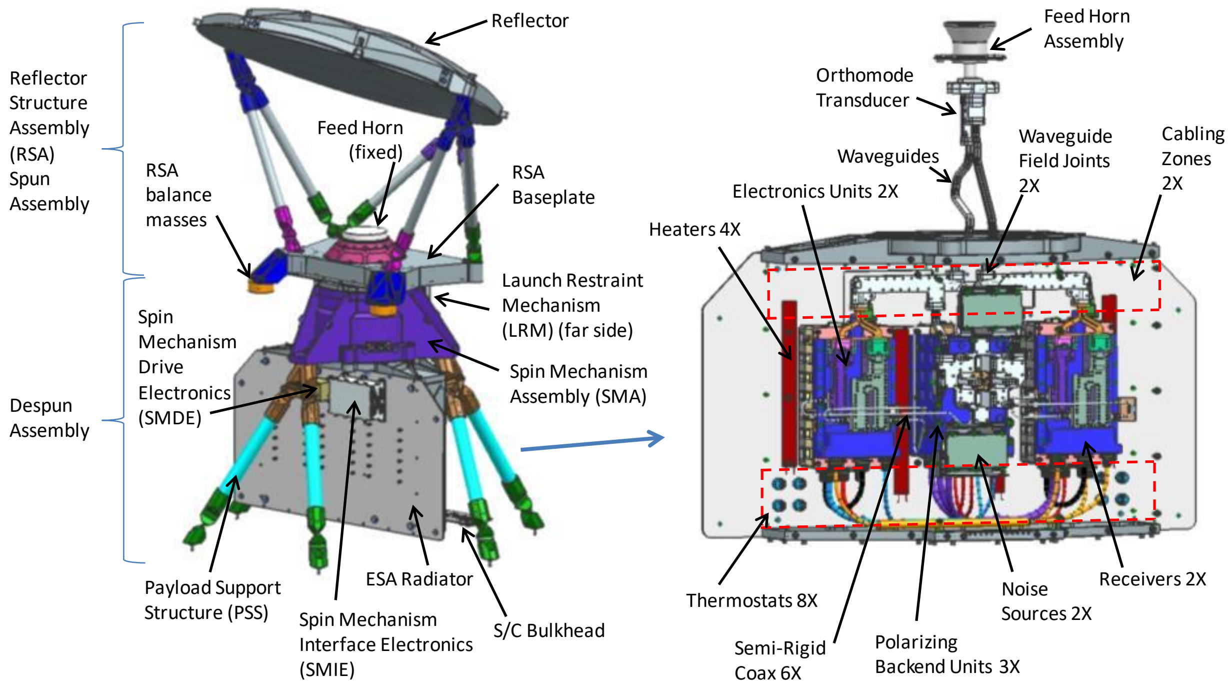


Figure 2-1. CAD representation of the COWVR instrument.

3 Data Products Overview

The COWVR ground data processing system (GDPS) produces three main data products, the Raw Data Record (RDR), Temperature Sensor Data Record (TSDR) and Environmental Data Record (EDR). Each file uses the Hierarchical Data Format, Version 5 (HDF-5) format. The RDR contains the raw unmodified COWVR telemetry packets converted into the HDF format along with raw unmodified spacecraft attitude and ephemeris for a time range that bounds the COWVR telemetry in the file. The STDR contains calibrated, geo-located antenna temperature and brightness temperatures along with the sensor telemetry used to derive those values. This product is best suited for a cal/val user or sensor expert. The EDR contains retrieval products and brightness temperatures and is best suited for the user interested in geophysical interpretation of the sensor data. This document describes the EDR product and some intermediate ancillary data.

4 Environmental Data Record (EDR) Product Format Description

The EDR contains 8 groups described below:

- **Metadata** : contains top level information about the file contents
- **Geolocation**: provides geolocation and geometric information for spacecraft and each COWVR observation
- **Calibrated Scene Temperatures:** Provides calibrated brightness temperatures
- **Diagnostics:** Provides…
- **Gridded Geolocation and Flags:** Geolocation parameters resampled to Earth grid
- **Gridded Scene Temperatures:** Calibrated scene brightness temperatures resampled to Earth grid
- **Gridded Ancillary Parameters:** Meteorological and other ancillary parameters resampled to Earth grid
- **Environmental Data Records:** Provides retrieved environmental variables

4.1. Metadata

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
InputPointer	VarLenStr	InputPtr		A pointer to one or more data granules that provide the major input that was used to generate this product.		
AncillaryDataDescriptors	VarLenStr	AncFile		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).		
CollectionLabel	VarLenStr	Scalar		Label of the data collection containing this product.		
SizeMBECSDataGranule	Float32	Scalar	Mbyte	The size of this data granule in megabyte.		
RangeBeginningDate	FixLenStr	Scalar		The date on which the earliest data contained in the product were acquired (yyyy-mm-dd).		
RangeEndingDate	FixLenStr	Scalar		The date on which the latest data contained in the product were acquired (yyyy-mm-dd).		
RangeBeginningTime	FixLenStr	Scalar		The time at which the earliest data contained in the product were acquired (hh:mm:ss.mmmZ).		
RangeEndingTime	FixLenStr	Scalar		The time at which the latest data contained in the product were acquired (hh:mm:ss.mmmZ).		
ProductionDateTime	FixLenStr	Scalar		The date and time at which the product was created (yyyy-mm-ddThh:mm:ss.mmmZ).		

SISName	VarLenStr	Scalar		The name of the document describing the contents of the product.		
SISVersion	VarLenStr	Scalar		The version of the document describing the contents of the product.		
BuildId	VarLenStr	Scalar		The ID of build that included the software that created this product.		
QAGranulePointer	VarLenStr	Scalar		A pointer to the quality assessment product that was generated with this product.		
GranulePointer	VarLenStr	Scalar		The filename of this product.		
LongName	VarLenStr	Scalar		A complete descriptive name for the data type of this product.		
ShortName	VarLenStr	Scalar		The short name identifying the data type of this product.		
ProducerAgency	VarLenStr	Scalar		Identification of the agency that provides the project funding.		
ProducerInstitution	VarLenStr	Scalar		Identification of the institution that provides project management.		
ProductionLocation	VarLenStr	Scalar		Facility in which this file was produced.		
ProductionLocationCode	FixLenStr	Scalar		None-letter code in filename indicating the ProductionLocation.		
ProcessingLevel	VarLenStr	Scalar		Indicates data level (Level 0, Level 1A, Level 1B, Level 1C, Level 2) in this product.		
InstrumentShortName	VarLenStr	Scalar		The name of the instrument that collected the telemetry data.		
PlatformLongName	VarLenStr	Scalar		The long name of the platform hosting the instrument.		
PlatformShortName	VarLenStr	Scalar		The short name of the platform hosting the instrument.		
PlatformType	VarLenStr	Scalar		The type of platform associated with the instrument that acquires the accompanying data.		
ProjectId	VarLenStr	Scalar		The project identification string.		
DataFormatType	FixLenStr	Scalar		A character string that indentifies the internal format of the data product.		
HDFVersionId	VarLenStr	Scalar		A character string that identifies the version of the HDF (Hierarchical Data Format) software that was used to generate this data file		
GranuleNumber	Singed32	Scalar		Granule counter for the mission		
ChunkNumber	Singed16	Scalar		A chunk counter used when the granule is subdivided for processing		

4.2. GeolocationAndFlags

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
obs_qual_flag	IntBitfield32	ObsRate_Array	none	Obs quality bit field tracking errors and degraded quality in processing.; 0: invalid time, 1: not nominal pkt, 2: bad angle time interp, 3: bad angle invalid epr index, 4: bad angle any reason, 5: suspect angle (vel interp), 6: skipped cal, 7: not sci obs, 8: missing posterior cal, 9: missing prior cal, 10: invalid input cals, 11: cal code buffer error, 12: cal degraded, 13: bad smoothed hk, 14: degraded smoothed hk, 15:failed path loss inversion, 16: non-monotonic time, 17: bad geo scan ang, 18: bad geo sc telem, 19: bad geo earth intersect, 20: bad geo range error, 21: failed geostat lat lon, 24: RFI, 25: sup arm obstruct, 26: solar arr obstruct, 27: cfov avg degraded, 28: cfov avg incomplete		
obs_index	Signed32	ObsRate_Array	none	Orbit granule obs index array for chunking realignment.		
time_string	FixLenStr	ObsRate_Array		UTC earth observation time.		
time_tai93	Float64	ObsRate_Array	s	TAI93 earth observation time.		
sat_alt	Float32	ObsRate_Array	m	Satellite altitude above earth WGS84 elipsoid.		
obs_lat	Float32	ObsRate_Array	deg	Observation latitude on Earth WGS84 ellipsoid.	-90	90
obs_lon	Float32	ObsRate_Array	deg	Observation longitude on Earth WGS84 ellipsoid.	-180	180
instr_scan_ang	Float32	ObsRate_Array	deg	Boresight scan angle in the instrument coordinate frame.	0	360
sc_scan_ang	Float32	ObsRate_Array	deg	Boresight scan angle relative to the spacecraft velocity vector in the spacecraft coordinate frame.	0	360
earth_pol_rot	Float32	ObsRate_Array	deg	Geometric polarization rotation angle wrt vertical at Earth observation.	0	360
earth_inc_ang	Float32	ObsRate_Array	deg	Sensor zenith angle wrt Earth observation	0	180
earth_az_ang	Float32	ObsRate_Array	deg	Sensor compass azimuth angle wrt Earth observation (0=pointing to north, 90=to east, 180=to south, 270=to west).	0	360
sun_glint_ang	Float32	ObsRate_Array	deg	Angle between specular reflection vector and vector to sun relative to surface normal	0	180

sc_att_flag	Signed8	ObsRate_Array	none	0 – nominal spacecraft attitude, 1 – off-nominal spacecraft attitude; -1: unknown	-1	1
fore_aft_flag	Signed8	ObsRate_Array	none	0 – observation is forward scan, 1 – observation is aft scan; -1: unknown	-1	1
asc_desc_flag	Signed8	ObsRate_Array	none	Satellite orbit node; 0: descending, 1: ascending, -1: unknown.	-1	1
land_flag	Signed8	ObsRate_Array	none	0 – ocean, 1 – coast, 2 – land; -1: unknown	-1	2
rain_flag	Signed8	ObsRate_Array	none	0: no rain, 1: possible rain, 2: rain, -1: unknown.	-1	2
rfi_flag	Signed8	ObsRate_Array	none	COWVR RFI flag (0=no reflection)	0	
solar array_flag	Signed8	ObsRate_Array	none	COWVR solar array obstruction flag (0=unobstructed).	0	
support_arm_flag	Signed8	ObsRate_Array	none	COWVR support arm obstruction flag (0=unobstructed).	0	
ufo_obstruct_flag	Signed8	ObsRate_Array	none	COWVR unknown obstruction flag (0=unobstructed).	0	
eph_source_flag	Signed8	ObsRate_Array	none	Ephemeris source; -1: unspecified, 0: transition, 1: gps, 2: issbad sto.	-1	2
att_source_flag	Signed8	ObsRate_Array	none	Attitude source; -1: unspecified, 0: transition, 1: flexcore nominal, 2: flexcore trac1 only, 3: flexcore trac2 only, 4: direct trac1, 5: direct trac2, 6: fixed tracker, 7: issbad sto.	-1	7

4.3. FineGriddedGeolocationAndFlags

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
fine_grid_lat	Float32	GridFineLatitude_Array	deg	Grid cell center latitudes (fine grid)	-90	90
fine_grid_lon	Float32	GridFineLongitude_Array	deg	Grid cell center longitudes (fine grid)	-180	180
fine_grid_num_obs_fore	Signed16	GridFine_latitude_GridFineLongitude_Array		Number of valid fore observations mapped to grid cell		
fine_grid_num_obs_aft	Signed16	GridFine_latitude_GridFineLongitude_Array		Number of valid aft observations mapped to grid cell		
fine_grid_land_flag	Signed8	GridFine_latitude_GridFineLongitude_Array		0: ocean, 1: land, 2: ambiguous, -1: unknown	-1	2
fine_grid_rfi_flag_fore	Signed8	GridFine_latitude_GridFineLongitude_Array		gridded fore COWVR RFI flag (0=no reflection)		
fine_grid_solar_array_flag_fore	Signed8	GridFine_latitude_GridFineLongitude_Array		gridded fore COWVR solar array obstruction flag (0=unobstructed)		
fine_grid_support_arm_flag_fore	Signed8	GridFine_latitude_GridFineLongitude_		gridded fore COWVR support arm obstruction flag (0=unobstructed)		

		Array				
fine_grid_ufo_obstruct_flag_fore	Signed8	GridFine_latitude_GridFineLongitude_Array		gridded fore COWVR unknown obstruction flag (0=unobstructed)		
fine_grid_asc_desc_flag_fore	Signed8	GridFine_latitude_GridFineLongitude_Array		gridded fore satellite orbit node (0=descending)		
fine_grid_rfi_flag_aft	Signed8	GridFine_latitude_GridFineLongitude_Array		gridded aft COWVR RFI flag (0=no reflection)		
fine_grid_solar_array_flag_aft	Signed8	GridFine_latitude_GridFineLongitude_Array		gridded aft COWVR solar array obstruction flag (0=unobstructed)		
fine_grid_support_arm_flag_aft	Signed8	GridFine_latitude_GridFineLongitude_Array		gridded aft COWVR support arm obstruction flag (0=unobstructed)		
fine_grid_ufo_obstruct_flag_aft	Signed8	GridFine_latitude_GridFineLongitude_Array		gridded aft COWVR unknown obstruction flag (0=unobstructed)		
fine_grid_asc_desc_flag_aft	Signed8	GridFine_latitude_GridFineLongitude_Array		gridded aft satellite orbit node (0=descending)		
fine_grid_time_tai93_fore	Float64	GridFine_latitude_GridFineLongitude_Array	s	Resampled fore TAI93 Earth observation time.		
fine_grid_time_tai93_aft	Float64	GridFine_latitude_GridFineLongitude_Array	s	Resampled aft TAI93 Earth observation time.		
fine_grid_instr_scan_ang_fore	Float32	GridFine_latitude_GridFineLongitude_Array	deg	Resampled boresight scan angle in the instrument coordinate frame.	0	360
fine_grid_instr_scan_ang_aft	Float32	GridFine_latitude_GridFineLongitude_Array	deg	Resampled boresight scan angle in the instrument coordinate frame.	0	360
fine_grid_earth_inc_ang_fore	Float32	GridFine_latitude_GridFineLongitude_Array	deg	Resampled fore satellite zenith angle wrt Earth observation.	0	180
fine_grid_earth_inc_ang_aft	Float32	GridFine_latitude_GridFineLongitude_Array	deg	Resampled aft satellite zenith angle wrt Earth observation.	0	180
fine_grid_earth_az_ang_fore	Float32	ObsRate_Stokes_Array	deg	Resampled fore satellite azimuth angle wrt Earth observation.	0	360
fine_grid_earth_az_ang_aft	Float32	GridFine_latitude_GridFin	deg	Resampled aft satellite azimuth angle wrt Earth observation.	0	360

		eLongitude_Array				

4.4. FineGriddedSceneTemperatures

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
fine_grid_tb18_ifov_fore	Float32	GridFine_latitude_GridFineLongitude_Stokes_Array	K	Resampled fore 18 GHz stokes brightness temperature at the instantaneous field of view (Earth polarization frame)		
fine_grid_tb23_ifov_fore	Float32	GridFine_latitude_GridFineLongitude_Stokes_Array	K	Resampled fore 23 GHz stokes brightness temperature at the instantaneous field of view (Earth polarization frame)		
fine_grid_tb34_ifov_fore	Float32	GridFine_latitude_GridFineLongitude_Stokes_Array	K	Resampled fore 34 GHz stokes brightness temperature at the instantaneous field of view (Earth polarization frame)		
fine_grid_tb18_ifov_aft	Float32	GridFine_latitude_GridFineLongitude_Stokes_Array	K	Resampled aft 18 GHz stokes brightness temperature at the instantaneous field of view (Earth polarization frame)		
fine_grid_tb23_ifov_aft	Float32	GridFine_latitude_GridFineLongitude_Stokes_Array	K	Resampled aft 23 GHz stokes brightness temperature at the instantaneous field of view (Earth polarization frame)		
fine_grid_tb34_ifov_aft	Float32	GridFine_latitude_GridFineLongitude_Stokes_Array	K	Resampled aft 34 GHz stokes brightness temperature at the instantaneous field of view (Earth polarization frame)		

4.5. CalibratedSceneTemperatures

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
tb18_ifov	Float32	ObsRate_Stokes_Array	K	Derived 18 GHz stokes brightness temperature at the instantaneous field of view (Earth polarization frame).		
tb23_ifov	Float32	ObsRate_Stokes_Array	K	Derived 23 GHz stokes brightness temperature at the instantaneous field of view (Earth polarization frame).		
tb34_ifov	Float32	ObsRate_Stokes_Array	K	Derived 34 GHz stokes brightness temperature at the instantaneous field of view (Earth polarization frame).		
tb18_cfov	Float32	ObsRate_Stokes_Array	K	Derived 18 GHz stokes brightness temperature at the composite field of view (Earth polarization frame).		
tb23_cfov	Float32	ObsRate_Stokes_Array	K	Derived 23 GHz stokes brightness temperature at the composite field of view (Earth polarization frame).		
tb34_cfov	Float32	ObsRate_Stokes_Array	K	Derived 34 GHz stokes brightness temperature at the composite field of view (Earth polarization frame).		

tb18_stdev	Float32	ObsRate_Stokes_Array	K	Derived 18 GHz stokes brightness temperature variance within the composite field of view (Earth polarization frame)		
tb23_stdev	Float32	ObsRate_Stokes_Array	K	Derived 23 GHz stokes brightness temperature variance within the composite field of view (Earth polarization frame)		
tb34_stdev	Float32	ObsRate_Stokes_Array	K	Derived 34 GHz stokes brightness temperature variance within the composite field of view (Earth polarization frame)		

4.6. Diagnostic

opt_cost	Float32	ScanAlongTrack_ScanCrossTrack_array				
opt_stat	Int16	ScanAlongTrack_ScanCrossTrack_array				
opt_num_fev	Int16	ScanAlongTrack_ScanCrossTrack_array				
opt_num_jev	Int16	ScanAlongTrack_ScanCrossTrack_array				

4.7. GriddedGeolocationAndFlags

grid_lat	Float32	GridLatitude_Array	Deg	Observation latitude on earth WGS84 elipsoid	-90.0	90.0
grid_lon	Float32	GridLongitude_Array	Deg	Observation longitude on earth WGS84 elipsoid	-180.0	180.0
grid_count	Signed16	GridLatitude_GridLongitude_Array		Number of potential observations mapped to bin		
grid_num_obs_fore	Signed16	GridLatitude_GridLongitude_Array		Number of valid fore observations mapped to grid cell		
grid_num_obs_aft	Signed16	GridLatitude_GridLongitude_Array		Number of valid aft observations mapped to grid cell		
grid_time_tai93_fore	Float64	GridLatitude_GridLongitude_Array	S	Resampled fore TAI93 Earth observation time.		
grid_time_tai93_aft	Float64	GridLatitude_GridLongitude_Array	S	Resampled aft TAI93 Earth observation time.		
grid_instr_scan_ang_fore	Float32	GridLatitude_GridLongitu	Deg	Resampled boresight scan angle in the instrument coordinate frame.	0.0	360.0

		de_Array				
grid_instr_scan_ang_aft	Float32	GridLatitude_GridLongitude_Array	Deg	Resampled boresight scan angle in the instrument coordinate frame.	0.0	360.0
grid_earth_inc_ang_fore	Float32	GridLatitude_GridLongitude_Array	Deg	Resampled fore satellite zenith angle wrt Earth observation	0	180.0
grid_earth_inc_ang_aft	Float32	GridLatitude_GridLongitude_Array	Deg	Resampled aft satellite zenith angle wrt Earth observation	0	180.0
grid_earth_az_ang_fore	Float32	GridLatitude_GridLongitude_Array	Deg	Resampled fore satellite azimuth angle wrt Earth observation	0	360.0
grid_earth_az_ang_aft	Float32	GridLatitude_GridLongitude_Array	Deg	Resampled aft satellite azimuth angle wrt Earth observation	0	360.0
grid_land_flag	Signed8	GridLatitude_GridLongitude_Array	none	0: ocean, 1: land, 2: ambiguous, -1: unknown	-1	2
grid_rain_flag	Signed8	GridLatitude_GridLongitude_Array	none	0: no rain, 1: possible rain, 2: rain, -1: unknown	-1	2
grid_rfi_flag_fore	Signed8	GridLatitude_GridLongitude_Array		gridded fore COWVR RFI flag (0=no reflection)		
grid_solar_array_flag_fore	Signed8	GridLatitude_GridLongitude_Array		gridded fore COWVR solar array obstruction flag (0=unobstructed)		
grid_support_arm_flag_fore	Signed8	GridLatitude_GridLongitude_Array		gridded fore COWVR support arm obstruction flag (0=unobstructed)		
grid_ufo_obstruct_flag_fore	Signed8	GridLatitude_GridLongitude_Array		gridded fore COWVR unknown obstruction flag (0=unobstructed)		
grid_asc_desc_flag_fore	Signed8	GridLatitude_GridLongitude_Array		gridded fore satellite orbit node (0=descending)		
grid_rfi_flag_aft	Signed8	GridLatitude_GridLongitude_Array		gridded aft COWVR RFI flag (0=no reflection)		
grid_solar_array_flag_aft	Signed8	GridLatitude_GridLongitude_Array		gridded aft COWVR solar array obstruction flag (0=unobstructed)		
grid_support_arm_flag_aft	Signed8	GridLatitude_GridLongitude_Array		gridded aft COWVR support arm obstruction flag (0=unobstructed)		
grid_ufo_obstruct_flag_aft	Signed8	GridLatitude_GridLongitude_Array		gridded aft COWVR unknown obstruction flag (0=unobstructed)		
grid_asc_desc_flag_aft	Signed8	GridLatitude_GridLongitude_Array		gridded aft satellite orbit node (0=descending)		

4.8. GriddedSceneTemperatures

grid_tb18_aft	Float32	GridLatitude_GridLongitude_Stokes_Array	K	Resampled 18 GHz stokes brightness temperature composite field of view scans into aft scan coordinates		
grid_tb23_aft	Float32	GridLatitude_GridLongitude_Stokes_Array	K	Resampled 23 GHz stokes brightness temperature composite field of view scans into aft scan coordinates		
grid_tb34_aft	Float32	GridLatitude_GridLongitude_Stokes_Array	K	Resampled 34 GHz stokes brightness temperature composite field of view scans into aft scan coordinates		
grid_tb18_fore	Float32	GridLatitude_GridLongitude_Stokes_Array	K	Resampled 18 GHz stokes brightness temperature interpolated from forward scans into aft scan coordinates		
grid_tb23_fore	Float32	GridLatitude_GridLongitude_Stokes_Array	K	Resampled 23 GHz stokes brightness temperature interpolated from forward scans into aft scan coordinates		
grid_tb34_fore	Float32	GridLatitude_GridLongitude_Stokes_Array	K	Resampled 34 GHz stokes brightness temperature interpolated from forward scans into aft scan coordinates		
grid_tb18 std_fore	Float32	GridLatitude_GridLongitude_Stokes_Array	K	Resampled spatial variance of fore observed 18 GHz stokes brightness temperature.		
grid_tb18 std_aft	Float32	GridLatitude_GridLongitude_Stokes_Array	K	Resampled spatial variance of aft observed 18 GHz stokes brightness temperature.		
grid_tb23 std_fore	Float32	GridLatitude_GridLongitude_Stokes_Array	K	Resampled spatial variance of fore observed 23 GHz stokes brightness temperature.		
grid_tb23 std_aft	Float32	GridLatitude_GridLongitude_Stokes_Array	K	Resampled spatial variance of aft observed 23 GHz stokes brightness temperature.		
grid_tb34 std_fore	Float32	GridLatitude_GridLongitude_Stokes_Array	K	Resampled spatial variance of fore observed 34 GHz stokes brightness temperature.		
grid_tb34 std_aft	Float32	GridLatitude_GridLongitude_Stokes_Array	K	Resampled spatial variance of aft observed 34 GHz stokes brightness temperature.		

4.9. GriddedAncillary

grid_anc_sst	Float32	GridLatitude_GridLongitude_Array	K	Gridded ancillary sea surface temperature		
grid_anc_wind_speed	Float32	GridLatitude_GridLongitude_Array	m/s	Gridded ancillary wind speed		
grid_anc_wind_dir	Float32	GridLatitude_GridLongitude_Array	deg	Gridded direction ancillary wind is blowing toward, degrees clockwise from North		

4.10. UngriddedEnvDataRecords

Name	**Data Type**	**Dimensions**	**Unit**	**Description**	**Minimum**	**Maximum**
ungridded_pwv	Float32	ObsRate_array	cm	Ungridded precipitable water vapor		
ungridded_clw	Float32	ObsRate_array	mm	Ungridded column liquid water		
ungridded_wind_speed	Float32	ObsRate_array	m/s	Ungridded wind speed		
ungridded_wind_speed_flag	Signed8	ObsRate_array	m/s	Quality flag for ungridded wind speed; 0: good, 1: bad, -1: unknown	-1	1

4.11. EnvDataRecords

Name	**Data Type**	**Dimensions**	**Unit**	**Description**	**Minimum**	**Maximum**
pwv_fore	Float32	GridLatitude_GridLongitude_Array	cm	Precipitable water vapor		
pwv_aft	Float32	GridLatitude_GridLongitude_Array	cm	Precipitable water vapor		
clw_fore	Float32	GridLatitude_GridLongitude_Array	mm	Column liquid water		
clw_aft	Float32	GridLatitude_GridLongitude_Array	mm	Column liquid water		
wind_dir_flag	Signed8	GridLatitude_GridLongitude_Array		Quality flag for wind direction; 0: good, 1: fore good aft ignored, 2: aft good fore ignored, 3: fore and aft degraded, 4: fore degraded aft ignored, 5: aft degraded fore ignored, 6: bad, -1: unknown	-1	6
wind_speed_flag	Signed8	GridLatitude_GridLongitude_Array		Quality flag for wind speed; 0: good, 1: fore good aft ignored, 2: aft good fore ignored,	-1	6

				3: fore and aft degraded, 4: fore degraded aft ignored, 5: aft degraded fore ignored, 6: bad, -1: unknown		
wind_speed	Float32	GridLatitude_GridLongitude_Array	m/s	wind speed		
wind_dir	Float32	GridLatitude_GridLongitude_Array	deg	Wind heading Direction retrieved wind is blowing toward, degrees clockwise from North		
wind_error	Float32	GridLatitude_GridLongitude_Array		RMSE between observed and modeled emissivity		
num_wind_amb	Signed16	GridLatitude_GridLongitude_Array		Number of ambiguities in retrieved wind direction		
wind_dir_amb	Float32	GridLatitude_GridLongitude_Array	deg	Ambiguity wind headings Ambiguities in retrieved direction wind is blowing toward, degrees clockwise from North		
wind_error_amb	Float32	GridLatitude_GridLongitude_Array		Ambiguity RMSE between observed and modeled emissivities		

5 Resampled Ancillary Product (Intermediate)

The AncResamp intermediate product contains 3 groups described below:

- **Metadata**: contains top level information about the file contents
- **Geolocation**: provides geolocation and geometric information for spacecraft and each COWVR observation
- **Ancillary**: provides additional information such as meteorological data needed for calculations.

5.1. Metadata

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
InputPointer	VarLenStr	InputPtr		A pointer to one or more data granules that provide the major input that was used to generate this product.		
AncillaryDataDescriptors	VarLenStr	AncFile		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).		
CollectionLabel	VarLenStr	Scalar		Label of the data collection containing this product.		
SizeMBECSDataGranule	Float32	Scalar	Mbyte	The size of this data granule in megabytes.		
RangeBeginningDate	FixLenStr	Scalar		The date on which the earliest data contained in the product were acquired (yyyy-mm-dd).		
RangeEndingDate	FixLenStr	Scalar		The date on which the latest data contained in the product were acquired (yyyy-mm-dd).		
RangeBeginningTime	FixLenStr	Scalar		The time at which the earliest data contained in the product were acquired (hh:mm:ss.mmmZ).		
RangeEndingTime	FixLenStr	Scalar		The time at which the latest data contained in the product were acquired (hh:mm:ss.mmmZ).		
ProductionDateTime	FixLenStr	Scalar		The date and time at which the product was created (yyyy-mm-ddThh:mm:ss.mmmZ).		
SISName	VarLenStr	Scalar		The name of the document describing the contents of the product.		
SISVersion	VarLenStr	Scalar		The version of the document describing the contents of the product.		
BuildId	VarLenStr	Scalar		The ID of build that included the software that created this product.		

GranuleNumber	Singed32	Scalar		Granule counter for the mission		
ChunkNumber	Singed16	Scalar		A chunk counter used when the granule is subdivided for processing		
QAGranulePointer	VarLenStr	Scalar		A pointer to the quality assessment product that was generated with this product.		
GranulePointer	VarLenStr	Scalar		The filename of this product.		
LongName	VarLenStr	Scalar		A complete descriptive name for the data type of this product.		
ShortName	VarLenStr	Scalar		The short name identifying the data type of this product.		
ProducerAgency	VarLenStr	Scalar		Identification of the agency that provides the project funding.		
ProducerInstitution	VarLenStr	Scalar		Identification of the institution that provides project management.		
ProductionLocation	VarLenStr	Scalar		Facility in which this file was produced.		
ProductionLocationCode	FixLenStr	Scalar		One-letter code in filename indicating the ProductionLocation.		
ProcessingLevel	VarLenStr	Scalar		Indicates data level (Level 0, Level 1A, Level 1B, Level 1C, Level 2) in this product.		
InstrumentShortName	VarLenStr	Scalar		The name of the instrument that collected the telemetry data.		
PlatformLongName	VarLenStr	Scalar		The long name of the platform hosting the instrument.		
PlatformShortName	VarLenStr	Scalar		The short name of the platform hosting the instrument.		
PlatformType	VarLenStr	Scalar		The type of platform associated with the instrument which acquires the accompanying data.		
ProjectId	VarLenStr	Scalar		The project identification string.		
DataFormatType	FixLenStr	Scalar		A character string thst indentifies the internal format of the data product.		
HDFVersionId	VarLenStr	Scalar		A character string that identifies the version of the HDF (Hierarchical Data Format) software that was used to generate this data file		

5.2. Geolocation

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
obs_index	Signed32	ObsRate_Array	none	Orbit granule obs index array for chunking realignment.		
time_string	FixLenStr	ObsRate_Array		UTC Earth observation time.		
time_tai93	Float64	ObsRate_Array	s	TAI93 Earth observation time.		
obs_qual_flag	IntBitfield32	ObsRate_Array	none	Obs quality bit field; 0: prev pkt missing, 1: not nominal pkt, 2: bad angle time interp, 3: bad angle invalid index, 4: suspect angle non-adj indices, 17: bad geo no scan ang, 18: bad geo sc telem, 19: bad geo earth intersect, 20: bad geo range error,		
obs_lat	Float32	ObsRate_Array	deg	Observation latitude on Earth WGS84 ellipsoid.	-90	90
obs_lon	Float32	ObsRate_Array	deg	Observation longitude on Earth WGS84 ellipsoid.	-180	180

5.3. Ancillary Parameters

anc_tec	Float32	ObsRate_Array	TEC unit	Line-of-sight ancillary total electron content		
anc_mag	Float32	ObsRate_Spatial_Array	Gauss	Ancillary magnetic field vector		
Beam_land_frac	Float32	ObsRate_SpectralCh_Array		Fraction of land in antenna main beam	0	1
anc_sst	Float32	ObsRate_Array	K	Amcillary sea surface temperature		
anc_wind_speed	Float32	ObsRate_Array	m/s	Ancillary wind speed		
anc_wind_dir	Float32	ScanAlongTrack_ScanCrossTrack_Array	deg	Ancillary wind direction relative to N		

6 Data Product Names

6.1. Product types and names

NOAA names for COWR data products:

RDR is Raw Data Record

TSDR is Temperature Sensor Data Record for sensor brightness temperature

EDR in Environmental Data Record (COWVR only)

NASA/JPL names for COWVR data products:

L0 extracts raw telemetry to H5 (note time-ordering for us is done upstream).

L1a applies DN-to-EU conversion on housekeeping, also geolocates science observations.

L1b applies calibration to the raw sensor counts to radiances (brightness temperatures).

L1c uses the scan geometry to resample the radiance to what Shannon calls cumulative FOV.

L2 retrieves the geophysical variables, such as wind speeds.

L1c is not an official NASA level, but missions sometimes use this to label processing needed between L1b (calibration) and L2.

There a mapping between the NOAA names and the NASA/JPL names is

RDR = L0

TSDR = L1c

EDR = L2

Our order of processing is mapped into separate executables for convenience. Not all the steps need to result in granules for data archive/distribution (or vise-versa).

For the processing of pre-launch ground test data, most data can only be processed through L1a, and a limited set can be processed through L1b. None can go further for the pre-launch ground test data.

6.2. File Naming Format

Two types of naming formats are used, one for the telemetry data downloaded from the ISS through the HOSC, and the product files generated in the GDPS.

6.2.1. Telemetry file name format

Telemetry file names will take the form:

APID(apid)_SEQ(SSSSSS)_StartDateTime(YYYYMMDDThhmmss)_FulfilledDateTime(YYYYMMDDThhmmss)_Duration(mmm)_Location(C).ext

where:

apid - the 4 digit APID of the telemetry data (see section 6)
SSSSSS - the granule ID of the product. It is generated from a sequence number calculated from the number of hours since the launch of the COWVR instrument
YYYYMMDDThhmmss - The year, month, date, hour, minute, second of the starting time of the requested data, with a "T" separator between the date and time.
mmm - Duration of the requested data in minutes
C - Location code that the data came from:
S: Simulated
H: HOSC low (2 hour) latency data
N: HOSC nominal (24 hour) latency data
J: JPL
L: Legacy files
P: Production
T: Test
ext - file extension:
pkt: Instrument packets
met: Metadata file describing packet file
XFR: Transfer notification file containing file name and md5sum of packet file
h5: HDF-5 file format

6.2.2. Science Data Products

inst_typ.GID(SSSSSS).StartDateTime(YYYYMMDDThhmmss).EndDateTime(YYYYMMDDTmmhhss).CollectionLabel(cv),LocationCode(C),ProductionTime(YYYYMMDDThhmmss).ext

where:

inst - Instrument: COWVR, TEMPEST
typ - Data type: RDR, L1A, L1B, GAIN, ANE, GEO, ANC, L1C, TSDR, EDR
GID - Granule ID; number of hours since defined epoch 2022-01-01
StartDateTime - Requested starting date and time of data
EndDateTime - Requested ending data and time of data
cv - Collection label (currently "v2")
All other fields same as in 8.2.1

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