Temporal Experiment for Storms and Tropical Systems (TEMPEST)

Temperature Sensor Data Record Data Product Description Document

8.0

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CHANGE LOG

DATE	SECTIONS CHANGED	REASON FOR CHANGE	REVISION
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09/20/22	4.4, 4.5, 5.3, 5.8-5.12	Release 7.3.5	
02/22/2023	3.2, 3.3	Release 7.4.0, separation into TSDR DPDD	Initial Release
8/22/2023	NONE	Re-released for B8.0 unchanged	

Table of Contents

1 Introduction

1.1 Purpose and Scope

This Temporal Experiment for Storms and Tropical Systems (TEMPEST) Data Product Description Document (DPDD) describes the contents of the products generated from the TEMPEST instrument data.

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 TEMPEST instrument, illustrated in Figure 1.1, comprises a scanning antenna assembly, single multi-frequency feed horn and five direct detection microwave receivers. The center frequencies are at 87, 164, 174, 178 and 181 GHz. The antenna scans at 30 RPM in the cross-track direction providing views of the Earth scene and calibration targets. A blackbody absorber is viewed at the top of the scan in the zenith direction and cold space is viewed at the scan edge. The radiometer integrates samples for 5ms. The receivers use Indium Phosphide low-noise amplifiers, a first for a spaceborne radiometer, giving the sensor a lower noise temperature than other radiometers on-orbit at similar frequencies. The sensor mass is 3.8kg and it operates with 6.5W of power. The spatial resolution at nadir is 25 km for the 87 GHz channel and 13 km for the 180 GHz channels. The swath width is 1400 km.

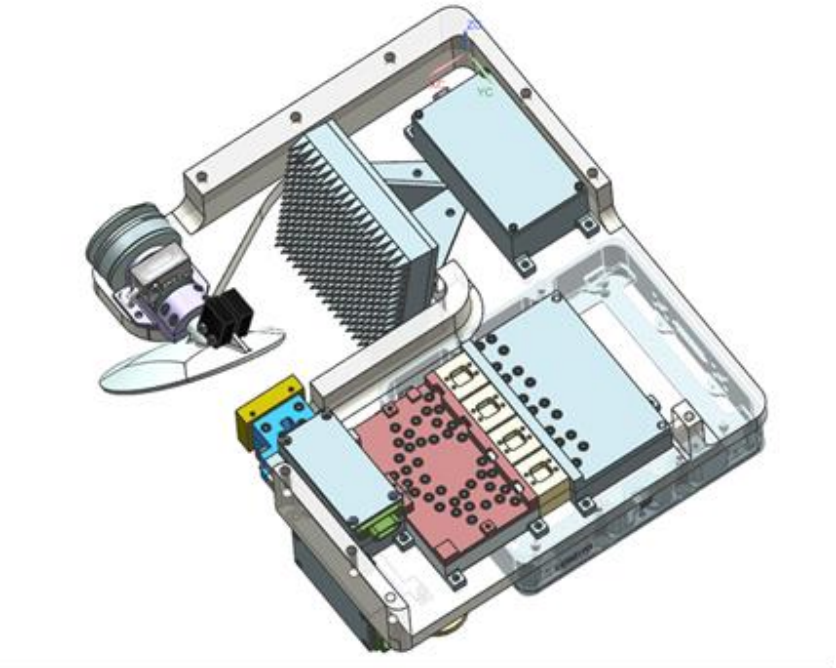

Figure 1.1. TEMPEST

2 Overview of TEMPEST

This TEMPEST instrument is a spare for the original TEMPEST-D instrument that was launched in May 2018 and flown as a CubeSat mission. It was developed by JPL under the NASA Earth Science Technology Office (ESTO) In-Space Validation of Earth Science Technologies (InVest) program, and provided to the Air Force by NASA, as a mission enhancement on the sponsor's H8 mission, scheduled for a mid-2021 launch. The mission will demonstrate the adaptation of the instrument to the H8/ISS platform (TEMPEST-H8). JPL will perform the on-orbit calibration and validation associated with TEMPEST-H8, drawing on its experience with the TEMPEST-D CubeSat mission.

The TEMPEST-H8 on-orbit performance is expected to be equivalent to the demonstrated on-orbit performance of TEMPEST-D, which achieves 1 Kelvin radiometric accuracy and typical 0.5 Kelvin resolution. TEMPEST-D continues to perform nominally on orbit since its commissioning in September 2018, having provided valuable measurements of the structure of Hurricanes Dorian and Florence, and other storm systems.

3 Data Products Overview

The TEMPEST ground data processing system (GDPS) produces two main data products, the Raw Data Record (RDR) and the Temperature Sensor Data Record (TSDR). Each file uses the Hierarchical Data Format, Version 5 (HDF-5) format. The RDR contains the raw unmodified TEMPEST telemetry packets converted into the HDF format along with raw unmodified spacecraft attitude and ephemeris for a time range that bounds the TEMPEST telemetry in the file. The TSDR 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. This document describes the TSDR product.

4 Temperature Sensor Data Record (TSDR) Product Format Description

The TSDR contains the groups described below:

- **Metadata** : contains top level information about the file contents
- **Frameheader**: provides time formation for each packet in the file
- **Geolocation**: provides geolocation and geometric information for spacecraft and each TEMPEST observation as well as surface flags
- **Ancillary**: Additional ancillary data needed for processing
- **Instrument Temperatures**: provides time series of TEMPEST measured instrument temperatures
- **Diagnostic**: Additional diagnostic data needed for calibration
- **Calibrated Antenna Temperatures**: Derived temperatures of antenna elements
- **Calibrated Scene Temperatures**: Derived temperatures of scenes
- **Warm Calibration Data**: Sensor data collected during warm calibration
- **Cold Calibration Data**: Sensor data collected during cold calibration
- **CalibrationData**: Calibration data from antenna scans
- **Geolocation Fore**: Forward geolocation data
- **Geolocation Aft**: Aft geolocation data
- **Scene Temps Fore**: Derived forward scene temperatures
- **Scene Temps Aft**: Derived aft scene temperatures
- **Remapped Packet**: Counts of samples from each temperature sensor

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 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.		
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		

4.2 FrameHeader

Name	**Data Type**	**Dimensions**	**Unit**	**Description**	**Minimum**	**Maximum**
frame_time_string	FixLenStr	FrameRate_Array		UTC instrument packet time.		
frame_time_tai93	Float64	FrameRate_Array	s	TAI93 instrument packet time.		
frame_qual_flag	IntBitfield16	FrameRate_Array	none	Instrument packet processing bit field; 0: prev pkt missing, 15: fill pkt.		

4.3 Geolocation

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
time_string	FixLenStr	ObsRate_Array		UTC Earth observation time.		
time_tai93	Float64	ObsRate_Array	s	TAI93 Earth observation time.		
Instr_scan_ang	Float32	ObsRate_Array	Deg	Instrument scan angle.	0.0	360.0
scan_pos	Signed8			Position in scan (1-100) of sample	1	100
sat_pos_eci	Float32	ObsRate_Spatial_Array	meter	Spacecraft position in the Earth Centered Inertial (ECI) coordinates (X, Y, Z)		
sat_pos_ecr	Float32	ObsRate_Spatial Array	meter	Spacecraft position in the Earth Centered Rotational (ECR) coordinates (X, Y, Z)		
sat_vel_eci	Float32	ObsRate_Spatial_Array	m/s	Spacecraft velocity in ECI coordinates (dx/dt, dy/dt, dz/dt)		
sat_vel_ecr	Float32	ObsRate_Spatial_Array	m/s	Spacecraft velocity in ECR coordinates (dx/dt, dy/dt, dz/dt)		
sat_lat	Float32	ObsRate_Array	deg	Sub-satellite latitude.	-90	90
sat_lon	Float32	ObsRate_Array	deg	Sub-satellite longitude.	-180	180
sat_alt	Float32	ObsRate_Array	m	Satellite altitude above Earth WGS84 elipsoid.		
sat_roll	Float32	ObsRate_Array	deg	Satellite roll angle (Euler order: 3,2,1).	-180	180
sat_pitch	Float32	ObsRate_Array	deg	Satellite pitch angle (Euler order: 3,2,1).	-180	180
sat_yaw	Float32	ObsRate_Array	deg	Satellite yaw angle (Euler order: 3,2,1).	-180	180
tempest_roll	Float32	ObsRate_array	Deg	Tempest roll angle (Euler order: 3,2,1).	-180	180
tempest_pitch	Float32	ObsRate_array	Deg	Tempest pitch angle (Euler order: 3,2,1).	-180	180
tempest_yaw	Float32	ObsRate_array	Deg	Tempest yaw angle (Euler order: 3,2,1).	-180	180
sat_solar_zen	Float32	ObsRate_Array	deg	The zenith angle of the Sun at the satellite.	0	180

sat_solar_az	Float32	ObsRate_Array	deg	The azimuth angle of the Sun at the satellite.	0	360
sat_lunar_zen	Float32	ObsRate_Array	deg	The zenith angle of moon at the satellite.	0	180
sat_lunar_az	Float32	ObsRate_Array	deg	The azimuth angle of the moon at the satellite.	0	360
sat_caa	Float32	ObsRate_Array	deg	The azimuth angle of the instrument boresight at the satellite.	0.0	360.0
Instr_boresight_ecr	Float32		M	Boresight unit vector (projected from instrument) in the Earth Centered Rotational (ECR) coordinates (X, Y, Z).		
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
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	Boresight incidence angle at Earth observation	0	180
earth_az_ang	Float32	ObsRate_Array	deg	Boresight azimuth angle at Earth observation	0	360
sun_glint_ang	Float32	ObsRate_Array	deg	Angle between specular reflection vector and vector to Sun relative to surface normal	0	180
obs_qual_flag	IntBitfield32	ObsRate_Array	none	17: bad geo no scan ang, 18: bad geo sc telem, 19: bad geo earth intersect, 20: bad geo range error.		
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

4.4 Ancillary

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
obs_land_flag	Signed8	ObsRate_Array		Land flag: -1=Unknown 0=Ocean 1=Inland_Water 2=Ice 3=Land		

4.5 InstrumentTemperatures

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
temp_cal1	Float32	FrameRate_Array	K	Measured temperature for calibration target #1		

temp_cal2	Float32	FrameRate_Array	K	Measured temperature for calibration target #2		
temp_cal3	Float32	FrameRate_Array	K	Measured temperature for calibration target #3		
temp_pdiv_wr5	Float32	FrameRate_Array	K	Measured temperature for WR5 power divider		
temp_fe_wr5	Float32	FrameRate_Array	K	Measured temperature for WR5 front-end		
temp_fe_wr10	Float32	FrameRate_Array	K	Measured temperature for WR10 front-end		
temp_ref	Float32	FrameRate_Array	K	Measured temperature for 4.99 kOhm reference resistor		

4.6 Diagnostic

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
mean_adc_temp	Float32	ObsRate_Array	K	Mean value of sensors c, d, and e used by calibration		

4.7 SinglePointCalibratedAntennaTemperatures

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
Sp_wl_ta182	Float32	ObsRate_Array		Single-point warm load calibrated 182GHz stokes antenna temperature		
Sp_wl_ta180	Float32	ObsRate_Array		Single-point warm load calibrated 180GHz stokes antenna temperature		
Sp_wl_ta176	Float32	ObsRate_Array		Single-point warm load calibrated 176GHz stokes antenna temperature		
Sp_wl_ta165	Float32	ObsRate_Array		Single-point warm load calibrated 165GHz stokes antenna temperature		
Sp_wl_ta89	Float32	ObsRate_Array		Single-point warm load calibrated 89GHz stokes antenna temperature		
Sp_cs_ta182	Float32	ObsRate_Array		Single-point cold sky calibrated 182GHz stokes antenna temperature		
Sp_cs_ta180	Float32	ObsRate_Array		Single-point cold sky calibrated 180GHz stokes antenna temperature		
Sp_cs_ta176	Float32	ObsRate_Array		Single-point cold sky calibrated 176GHz stokes antenna temperature		
Sp_cs_ta165	Float32	ObsRate_Array		Single-point cold sky calibrated 165GHz stokes antenna temperature		
Sp_cs_ta89	Float32	ObsRate_Array		Single-point cold sky calibrated 89GHz stokes antenna temperature		

4.8 TwoPointCalibratedAntennaTemperatures

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
tp_ta182	Float32	ObsRate_Array	K	Two-point gain based calibrated 182 GHz stokes antenna temperature		
tp_ta180	Float32	ObsRate_Array	K	Two-point gain based calibrated 180 GHz stokes antenna temperature		
tp_ta176	Float32	ObsRate_Array	K	Two-point gain based calibrated 176 GHz stokes antenna temperature		
Tp_ta165	Float32	ObsRate_Array	K	Two-point gain based calibrated 165 GHz stokes antenna temperature		
tp_ta89	Float32	ObsRate_Array	K	Two-point gain based calibrated 89 GHz stokes antenna temperature		

4.9 CalibratedSceneTemperatures

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
obs_qual_flag	IntBitfield32	ObsRate_Array	none	Obs quality bit field; 1: not valid pkt, 17: bad geo no scan ang 18: bad geo sc telem 19: bad geo earth intersect 20: bad range error	1	14
solar_array_flag	Signed8	ObsRate_Array		COWVR solar array obstruction flag (0=unobstructed).	0	1
tb182	Float32	ObsRate_Array	K	Derived 182 GHz stokes scene temperature		
tb180	Float32	ObsRate_Array	K	Derived 180 GHz stokes scene temperature		
tb176	Float32	ObsRate_Array	K	Derived 176 GHz stokes scene temperature		
tb165	Float32	ObsRate_Array	K	Derived 165 GHz stokes scene temperature		
tb89	Float32	ObsRate_Array	K	Derived 89 GHz stokes scene temperature		

4.10 CalibrationData

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
cal_time_string	FixLenStr	CalRate_Array		Mean time of calibration cycle observations, UTC.		
cal_time_tai93	Float64	CalRate_Array	s	Mean time of calibration cycle		

				observations, TAI93 format.		
cal_wl_temp	Float32	CalibrationRate_Spectral_Array	K	Warm load brightness temperature for each scan		
cal_wl_adc_mean	Float32	CalibrationRate_Spectral_Array	DN	Mean warm load counts for each scan		
cal_wl_adc_std	Float32	CalibrationRate_Spectral_Array	DN	Standard deviation of warm load counts for each scan		
cal_cs_temp	Float32	CalibrationRate_Spectral_Array	K	Cold sky bcalibrationrightness temperature for each scan		
cal_cs_adc_mean	Float32	CalibrationRate_Spectral_Array	DN	Mean cold sky calibration counts for each scan		
cal_cs_adc_std	Float32	CalibrationRate_Spectral_Array	DN	Standard deviation of cold sky calibration counts for each scan		
cal_gain	Float32	CalibrationRate_Spectral_Array	DN	Standard deviation of cold sky calibration counts for each scan		

4.11 GeolocationFore

scan_marker_fore	Signed32	ScanAlongTrack_Array	deg	Canonical obs index that represents entire scan row.		
scan_qual_flag_fore	IntBitfield32	ScanAlongTrack_Array	deg	Selective rollup of obs_qual_flag to represent scan row.		
obs_index_fore	Signed32	ScanAlongTrack_ScanCrossTrack_Array	deg	Orbit-based obs index array for chunking realignment.		
time_string_fore	FixLenStr24	ScanAlongTrack_ScanCrossTrack_Array	deg	UTC Earth observation time.		
time_tai93_fore	Float64	ScanAlongTrack_ScanCrossTrack_Array	deg	TAI93 Earth observation time.		
inst_scan_ang_fore	Float32	ScanAlongTrack_ScanCrossTrack_Array	deg	Boresight scan angle in the instrument coordinate frame.		
obs_lat_fore	Float32	ScanAlongTrack_ScanCrossTrack_Array	deg	Observation latitude on Earth WGS84 elipsoid.		
obs_lon_fore	Float32	ScanAlongTrack_ScanCrossTrack_Array	deg	Observation latitude on Earth WGS84 elipsoid.		

4.12 GeolocationAft

scan_marker_aft	Signed32	ScanAlongTrack_Array	deg	Canonical obs index that represents entire scan row.		
scan_qual_flag_aft	IntBitfield32	ScanAlongTra	deg	Selective rollup of obs_qual_flag to		

		ck_Array		represent scan row.		
obs_index_aft	Signed32	ScanAlongTrack_ScanCrossTrack_Array	deg	Orbit-based obs index array for chunking realignment.		
time_string_aft	FixLenStr24	ScanAlongTrack_ScanCrossTrack_Array	deg	UTC Earth observation time.		
time_tai93_aft	Float64	ScanAlongTrack_ScanCrossTrack_Array	deg	TAI93 Earth observation time.		
inst_scan_ang_aft	Float32	ScanAlongTrack_ScanCrossTrack_Array	deg	Boresight scan angle in the instrument coordinate frame.		
obs_lat_aft	Float32	ScanAlongTrack_ScanCrossTrack_Array	deg	Observation latitude on Earth WGS84 elipsoid.		
obs_lon_aft	Float32	ScanAlongTrack_ScanCrossTrack_Array	deg	Observation latitude on Earth WGS84 elipsoid.		

4.13 SceneTempsFore

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
tb182_fore	Float32	ScanAlongTrack_ScanAcross_track_Array	K	Derived 182 GHz stokes scene temperature		
tb180_fore	Float32	ScanAlongTrack_ScanAcross_track_Array	K	Derived 180 GHz stokes scene temperature		
tb176_fore	Float32	ScanAlongTrack_ScanAcross_track_Array	K	Derived 176 GHz stokes scene temperature		
tb165_fore	Float32	ScanAlongTrack_ScanAcross_track_Array	K	Derived 165 GHz stokes scene temperature		
tb89_fore	Float32	ScanAlongTrack_ScanAcross_track_Array	K	Derived 89 GHz stokes scene temperature		

4.14 SceneTempsAft

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
tb182_aft	Float32	ScanAlongTrack_ScanAcross_track_Array	K	Derived 182 GHz stokes scene temperature		
tb180_aft	Float32	ScanAlongTrack_ScanAcross_track_Array	K	Derived 180 GHz stokes scene temperature		

tb176_aft	Float32	ScanAlongTrack_ScanAcross_track_Array	K	Derived 176 GHz stokes scene temperature		
tb165_aft	Float32	ScanAlongTrack_ScanAcross_track_Array	K	Derived 165 GHz stokes scene temperature		
tb89_aft	Float32	ScanAlongTrack_ScanAcross_track_Array	K	Derived 89 GHz stokes scene temperature		

4.15 RemappedPacket

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
ta182_count	Unsigned16	ObsRate_Array	counts	Raw detector counts for 182 GHz channel.	0	65536
ta180_count	Unsigned16	ObsRate_Array	counts	Raw detector counts for 182 GHz channel.	0	65536
ta176_count	Unsigned16	ObsRate_Array	none	Raw detector counts for 176 GHz channel.	0	65535
ta165_count	Unsigned16	ObsRate_Array	none	Raw detector counts for 165 GHz channel.	0	65535
ta89_count	Unsigned16	ObsRate_Array	none	Raw detector counts for 89 GHz channel.	0	65535

5 Ground Instrument Sample Product Format Description

The sample data files contain 3 groups stored in two files described below:

TEMPEST_L1 file:

- **Rad** : Radiance data
- **SC**: Spacecraft attitude and ephemeris

TEMPEST_Scan file:

Scan: Instrument scan data

5.1 Rad Group

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
SCalt	float	[1; 348900]	km	Spacecraft altitude at radiometer sample rate		
SCinc	float	[1; 348900]	degrees	Spacecraft off-nadir pointing angle from center of Earth		
SClat	float	[1; 348900]	degrees	Sub-spacecraft latitude at radiometer sample rate		
SClon	float	[1; 348900]	degrees	Sub-spacecraft longitude at radiometer sample rate		
SCpitch	float	[1; 348900]	degree	Spacecraft orientation: counter-clockwise rotation about the S/C y-axis		
SCroll	float	[1; 348900]	degree	Spacecraft orientation: counter-clockwise rotation about the S/C x-axis		
SCyaw	float	[1; 348900]	degree	Spacecraft orientation: counter-clockwise rotation about the S/C z-axis		
TA	float	[5; 348900]	K	Calibrated antenna temperature		
TAItime	double	[1; 348900]	s	TAI time of radiometer samples		
TAspCS	float	[5; 348900]	K	Single-point cold sky calibrated antenna temperature		
TAspWL	float	[5; 348900]	K	Single-point warm load calibrated antenna temperature		
TB	float	[5; 348900]	K	Calibrated brightness temperature		
UTCtime	double	[1; 348900]	s	UTC time of radiometer samples		
adc	float	[5; 348900]	digital number	Uncalibrated output voltage from analog to digital converter		
adc_temps	float	[8/8; 348900]	K	Thermistor data converted to Kelvin at radiometer sample rate		
adcpos	float	[1; 348900]	\\	Position in packet (1-100) of ADC sample		
asds	float	[1; 348900]	/	Ascending/Descending flag (asc=1;dsc=0)		
belev	float	[1; 348900]	degrees	Angle between boresight and center of Earth		
bhorz	float	[1; 348900]	degrees	Angle between boresight and Earth horizon		
binc	float	[1; 348900]	degrees	Boresight incidence angle at radiometer sample rate		
blat	float	[1; 348900]	degrees	Boresight latitude at radiometer sample rate		

blon	float	[1; 348900]	degrees	Boresight longitude at radiometer sample rate		
encoder	float	[1; 348900]		Encoder counts - 16384 CPR		
landfrac	float	[1; 348900]		Fraction of land in the main beam (0 to 1)		
landmask	float	[1; 348900]		Ocean=0; Inland Water=1; Land=3 - resolution is 2 minutes		
landmaskSC	float	[1; 348900]		Ocean=0; Inland Water=1; Land=3 - resolution is 2 minutes		
scanang	float	[1; 348900]	degrees	Scan angle from encoder		
scene	float	[1; 348900]		Scene code (0=cold sky;1=limb; 2=ocean; 5=land)		
trx	float	[5; 348900]	K	Parameterized receiver noise temperature		
useTLE	float	[1; 348900]		Flag to say if SOH (=0) or TLE (=1) were used to generate geolocation		

5.2 SC Group

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
ECI	float	[3; 5014]	km	x;y;z position in ECI frame		
Q_ECI	float	[4; 5014]		S/C body orientation quaternion in ECI frame		
R_ECI	float	[3; 3; 5014]		S/C body orientation rotation matrix in ECI frame		
R_ECI_LVL	float	[3; 3; 5013]		S/C body orientation rotation matrix for level flight in ECI frame		
UTCtime	double	[1; 5014]	s	UTC time of spacecraft telemetry		
alt	float	[5014; 1]	km	Spacecraft altitude		
asds	float	[5014; 1]	/	Ascending/Descending flag (asc=1;dsc=0)		
lat	float	[5014; 1]	degrees	Sub-spacecraft latitude		
lon	float	[5014; 1]	degrees	Sub-spacecraft longitude		
pitch	float	[1; 5014]	degree	Counter-clockwise rotation about the S/C y-axis		
roll	float	[1; 5014]	degree	Counter-clockwise rotation about the S/C x-axis		
yaw	float	[1; 5014]	degree	Counter-clockwise rotation about the S/C z-axis		

5.3 Scan Group

Name	Data Type	Dimensions	Unit	Description	Minimum	Maximum
SCalt	float	[1; 1892]	km	Spacecraft altitude at radiometer sample rate		
SCinc	float	[1; 1892]	degrees	Spacecraft off-nadir pointing angle		
SClat	float	[1; 1892]	degrees	Sub-spacecraft latitude at radiometer sample rate		
SClon	float	[1; 1892]	degre	Sub-spacecraft longitude at		

			es	radiometer sample rate		
SCpitch	float	[1; 1892]	degree	Spacecraft orientation: counter-clockwise rotation about the S/C y-axis		
SCroll	float	[1; 1892]	degree	Spacecraft orientation: counter-clockwise rotation about the S/C x-axis		
SCyaw	float	[1; 1892]	degree	Spacecraft orientation: counter-clockwise rotation about the S/C z-axis		
TA	float	[5; 400; 1892]	K	Calibrated antenna temperature: CH1=181GHz;CH2=178GHz;CH3=174GHz;CH4=164GHz;CH5=87GHz		
TB	float	[5; 400; 1892]	K	Calibrated brightness temperature: CH1=181GHz;CH2=178GHz;CH3=174GHz;CH4=164GHz;CH5=87GHz		
UTCtime	double	[400; 1892]	s	UTC time of radiometer samples		
adc	float	[5; 400; 1892]	digital number	Uncalibrated output voltage from analog to digital converter: CH1=181GHz;CH2=178GHz;CH3=174GHz;CH4=164GHz;CH5=87GHz		
adc_temps	float	[8; 1892]	K	Thermistor data converted to Kelvin		
asds	float	[1; 1892]		Ascending/Descending flag (asc=1;dsc=0)		
belev	float	[400; 1892]	degrees	Angle between boresight and center of Earth		
bhorz	float	[400; 1892]	degrees	Angle between boresight and Earth horizon		
binc	float	[400; 1892]	degrees	Boresight incidence angle at radiometer sample rate		
blat	float	[400; 1892]	degrees	Boresight latitude at radiometer sample rate		
blon	float	[400; 1892]	degrees	Boresight longitude at radiometer sample rate		
landmask	float	[400; 1892]		Ocean=0; Inland Water=1; Land=3 - resolution is 2 minutes		
landmaskSC	float	[400; 1892]		Ocean=0; Inland Water=1; Land=3 - resolution is 2 minutes		

6 Data Product Names

6.1 Product types and names

NOAA names for TEMPEST data products:

RDR is Raw Data Record

TSDR is Sensor brightness temperature Data Record

NASA/JPL names for TEMPEST 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).

Therefore, a mapping between the NOAA names and the NASA/JPL names is

RDR = L0

TSDR = L1b

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 latency (2 hour) data
N: HOSC nominal latency (24 hour) 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(YYYYMMDD Tmmhhss).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 7.2.1

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