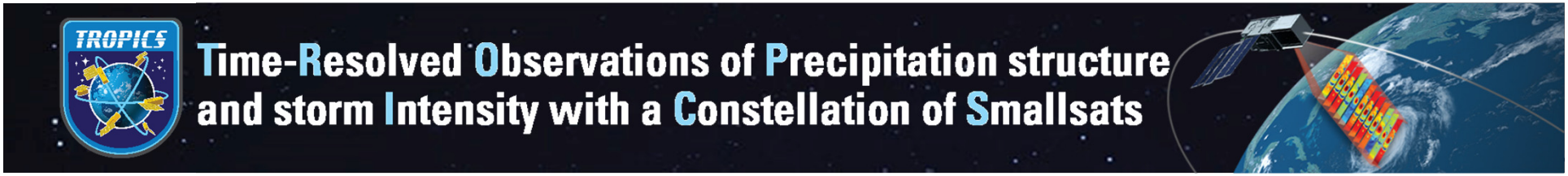


Data Products and Proxy Data

TROPICS 2018Q2 Quarterly Applications Call

TROPICS Science Team

29 June 2018

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Outline

- Data Product Overview
- L1 and L2a Filename Nomenclature
- L1 and L2a Data Format
- Proxy Data Science
- Release Plan

Data Product Highlights

- TROPICS is required to deliver data in netCDF4 format, but Brad is working with the applications community to generate other formats such as BUFR and GIS-compatible files for general dissemination
- Once operational (~ 90 days after first launch), data will be available at GES DISC DAAC (https://disc.gsfc.nasa.gov/) with quicklook images
- L2b geophysical retrievals will use MIRS netCDF output (see https://www.star.nesdis.noaa.gov/mirs/documentation.php)
- Public documentation (potentially hosted by GES DISC):
  - Algorithm Theoretical Basis Documents (ATBD)
    - Payload description
    - Algorithm description
    - Pre-launch test data verification
  - Data user's guide
    - Data format and quality flags
    - Data access at GES DISC
    - Validation Plan
    - Validation Report (post-launch appendix)

TROPICS Data Products

Data Product Level Designation	Data Product Description	Team Member (Org.)
Level 0	raw CCSDS payload and telemetry from space vehicles	Shawn Donnelly & Nick Zorn (LL)
1 Level 1a	Timestamped, geolocated, calibrated antenna temperature	Vince Leslie (LL)
Level 1b	Timestamped, geolocated, calibrated brightness temperature with bias removed	Vince Leslie (LL)
2 Level 2a	Spatially resampled (i.e., collocated) G-band brightness temperature (to F-band resolution)	Ralf Bennartz (UWisc-Madison/Vanderbilt)
Level 2b 3	Atmospheric Vertical Temperature Profile [Kelvin]	Tom Greenwald (UWisc-Madison) & Ralf Bennartz
	Atmospheric Vertical Moisture Profile [g/kg]	Tom Greenwald & Ralf Bennartz
	Instantaneous Surface Rain Rate [mm/hr]	Tom Greenwald & Ralf Bennartz
4	TC Intensity: Minimum Sea-Level Pressure [mb]	A) Derrick Herndon & Chris Velden (UWisc-Madison) B) Galina Chirokova (CSU/CIRA) & Mark DeMaria (NHC)
	TC Intensity: Maximum Sustained Wind [m/s]	A) Derrick Herndon & Chris Velden B) Galina Chirokova & Mark DeMaria

Red boxes indicate separate ATBDs and the algorithms they cover

L1 & L2a Filename Nomenclature

TROPICS_L<DP_ID>_SV<*SV_ID*>_Orbit<*Orbit#*>_*ST*<*YYYYMMDD-HHmmSS*>_ET<*YYYYMMDD-HHmmSS*>_*CT*<*YYYYMMDD-HHmmSS*>.nc

<DP_ID> represents one of the three radiance data products: 1A are the antenna temperature, 1B are the brightness temperatures, and 2A are the unified G-band radiances.

<SV_ID> represents one of the six satellites in the TROPICS constellation (01→06)

<Orbit#> represents the orbit number since released from the launch vehicle. It will range from 00000 to 99999 (~ 18 years worth).

<YYYYMMDD-HHmmSS> represents 20180201-080122 or February 2, 2018 08:01:22 AM. These times refers to either the start time (ST), end time (ET), or creation time (CT) of the science data packets (or file).

The TROPICS granule, i.e., duration of the file, will be an entire orbit, which an orbit is defined as the maximum latitude to max. latitude.

L1a Data Format (1 of 4)

Description of the TROPICS Level-1a Data Product

Long Name	Short Name	Dimension	Data Type	Description	Units (Valid Range of Values)
Space Vehicle ID	SV_ID	1	4-bit unsigned integer	Spacecraft Identifier	1 to 7
Orbit Number	Orbit	1	16-bit unsigned integer	Number of orbits since launch	1-10000
Algorithm Version	AlgVer	2 (major & minor revisions)	4-bit unsigned integer	Calibration algorithm version number with corresponding release notes on changes (major and minor number)	0-16
File Creation Time	FCTime	1	64-bit integer	Elapsed UTC timestamp of the file's creation time	Microseconds from epoch (Jan. 1, 2000)
ScanN	ScanN	1	16-bit unsigned integer	The number of scans in a TROPICS granule (i.e., file)	1-5000
EarthN	EarthN	1	8-bit unsigned integer	The number of measurements in the Earth scene	81
SpaceN	SpaceN	ScanN	8-bit unsigned integer	The number of deep space measurements with ND "off" in the space view sector for each scan	10-159
NoiseDiodeN	NoiseDiodeN	ScanN	8-bit unsigned integer	The number of noise diode measurements with ND "on" at the end during a limb sector for each scan	10-159
W- & F-band Polarization Angle	WFPolAngle	1	32-bit float	The measured W- & F-band fixed polarization angle for this spacecraft (referenced from velocity vector, i.e., RAM, in clockwise rotation)	0 - 360 degrees
G-band Polarization Angle	GPolAngle	1	32-bit float	The measured G-band fixed polarization angle for this spacecraft (referenced from velocity vector, i.e., RAM, in clockwise rotation)	0 - 360 degrees

Preliminary: Subject to Change

L1a Data Format (2 of 4)

Long Name	Short Name	Dimension	Data Type	Description	Units (Valid Range of Values)
S/C Position	SC_POS	ScanN x [x, y, z]	32-bit float	The spacecraft position every scan (at nadir timestamp) in ECEF coordinate system	km (-10,000 to 10,000)
S/C Velocity	SC_VEL	ScanN x [dx/dt, dy/dt, dz/dt]	32-bit float	The spacecraft velocity every scan (at nadir timestamp) in ECEF coordinate system	meters/second (0 to 10,000)
S/C Attitude	SC_ATT	ScanN x [row, pitch, yaw]	32-bit float	The spacecraft attitude (roll, pitch, & yaw) every scan (at nadir timestamp) in ECEF coordinate system	arcseconds (-X to X)
Earth Scene Measurement Time	ESTime	EarthN x ScanN	64-bit integer	Elapsed UTC timestamp of each Earth scene measurement during a scan	Microseconds from epoch (Jan. 1, 2000)
Calibration Measurement Time	CalTime	[SpaceN + NoiseDiodeN] (max within file) x ScanN	64-bit integer	Elapsed UTC timestamp of each measurement during a scan (Space sector then ND sector)	Microseconds from epoch (Jan. 1, 2000)
Earth Scene Antenna Temperatures	ESAntTemp	12 channels x EarthN x ScanN	32-bit float	The Planck blackbody equivalent antenna temperatures of the Earth scene measurements	Kelvin (3-330)
Earth Scene Scan Angle	ESScanAng	12 channels x EarthN x ScanN	32-bit float	Scan angle of measurements from a vector pointing toward the Earth's center (i.e., includes S/C roll)	Degrees (-180 to 179.9999)
Earth Scene Incident Angle	ESIncAng	EarthN x ScanN	32-bit float	Earth incident angle of the intersection between the measurement LOS (i.e., to satellite) and a normal vector from the Earth scene's FOV center.	Degrees (0 to 90)
Earth Scene Azimuth Angle	ESAziAng	EarthN x ScanN	32-bit float	Azimuth angle (measured clockwise positive from North) to the satellite at the geolocated Earth scene's FOV center.	Degrees (0 to 360)

Preliminary: Subject to Change

L1a Data Format (3 of 4)

Long Name	Short Name	Dimension	Data Type	Description	Units (Valid Range of Values)
Latitude of Earth Scene	ESLat	12 channels x EarthN x ScanN	32-bit float	Geodetic latitude of the Earth scene measurement on the surface of the Earth	Degrees (-40 to 40)
Longitude of Earth Scene	ESLon	12 channels x EarthN x ScanN	32-bit float	Geodetic longitude of the Earth scene measurement on the surface of the Earth	Degrees (-180 to 179.9999)
Earth Scene Lunar Incident Angle	LunIncAng	EarthN x ScanN	32-bit float	Lunar incident angle of the intersection between the lunar LOS and a normal vector from the Earth scene's FOV center.	Degrees (0 to 90)
Earth Scene Lunar Azimuth Angle	LunAziAng	EarthN x ScanN	32-bit float	Azimuth angle (measured clockwise positive from North) to moon at the geolocated Earth scene's FOV center.	Degrees (0 to 360)
Earth Scene Solar Incident Angle	SolIncAng	EarthN x ScanN	32-bit float	Solar incident angle of the intersection between the solar LOS and a normal vector from the Earth scene's FOV center.	Degrees (0 to 90)
Earth Scene Solar Azimuth Angle	SolAziAng	EarthN x ScanN	32-bit float	Azimuth angle (measured clockwise positive from North) to sun at the geolocated Earth scene's FOV center.	Degrees (0 to 360)
Calibration Gain	CalGain	12 channels x ScanN	32-bit float	The channels calculated calibration gain for each scan (at nadir timestamp)	Counts/Kelvin (0 to 1000)
Calibration Offset	CalOffset	12 channels x ScanN	32-bit float	The channels calculated calibration offset for each scan (i.e., radiometric counts of the space sector) at nadir timestamp	Counts (0 to 2^16)
Calibration Sector Antenna Temperature	CalAntTemp	12 channels x [SpaceN + NoiseDiodeN] (max within file) x ScanN	32-bit float	The Planck blackbody equivalent antenna temperature of the deep space and deep space with ND on measurements	Kelvin (3 - 500)
Quadratic Correction	Quadratic	12 channels x EarthN x ScanN	32-bit float	Non-linearity correction that was applied to the Earth Scene measurements	Kelvin (0-10)

Preliminary: Subject to Change

L1a Data Format (4 of 4)

Long Name	Short Name	Dimension	Data Type	Description	Units (Valid Range of Values)
Intrusion Flag	IntrusionFlag	12 channels x [SpaceN + NoiseDiodeN] (max within file) x ScanN	1-bit integer	Flag that indicates whether Earth, lunar or solar intrusion is likely	0 (no intrusion) or 1 (likely intrusion)
Calibration Sector Consistency Flag	CalConsistFlag	12 channels x [SpaceN + NoiseDiodeN] (max within file) x ScanN	1-bit integer	Flag that indicates if the calibration sector measurements are consistent (i.e., no outliers)	0 (consistent with each other) or 1 (inconsistent)
Data Gap Flag	DataGapFlag	ScanN	2-bit integer	Flag to indicates whether 1) intra-scan gap or 2) gap between scans	0 (no gap) , 1 (gap between previous scan), 2 (intra-scan gap), or 3 (both intra-scan gap and gap with previous scan)

Preliminary: Subject to Change

L1b Data Format

Description of the TROPICS Level-1b Data Product

Variable	Short Name	Dimensions	Data Type	Description	Units (Valid Range of Values)
All Level-1a Fields except the Earth Scene Antenna Temperatures (ESAntTemp)					
Earth Scene Brightness Temperatures	ESBriTemp	12 channels x EarthN x ScanN	32-bit float	The Planck blackbody equivalent brightness temperatures of the Earth scene measurements (all three corrections below, i.e., APC-1, APC-2, & APC-3, have been applied to Level-1a antenna temperature)	Kelvin (3-330)
Static Antenna Pattern Correction (multiplicative)	APC-1	12 channels x EarthN	32-bit float	The channel's static multiplicative antenna pattern correction for each Earth Scene (derived from antenna pattern measurements)	Unitless (0.9 to 1)
Static Antenna Pattern Correction (additive)	APC-2	12 channels x EarthN	32-bit float	The channel's additive antenna pattern correction for each Earth Scene derived from antenna pattern measurements	Kelvin (0 to 1)
Dynamic Antenna Pattern Correction (additive)	APC-3	12 channels x EarthN x ScanN	32-bit float	The channel's additive antenna pattern correction for each Earth Scene and each scan (derived from NWP/RTM comparison)	Kelvin (0 to 1)

Preliminary: Subject to Change

L2a Data Format

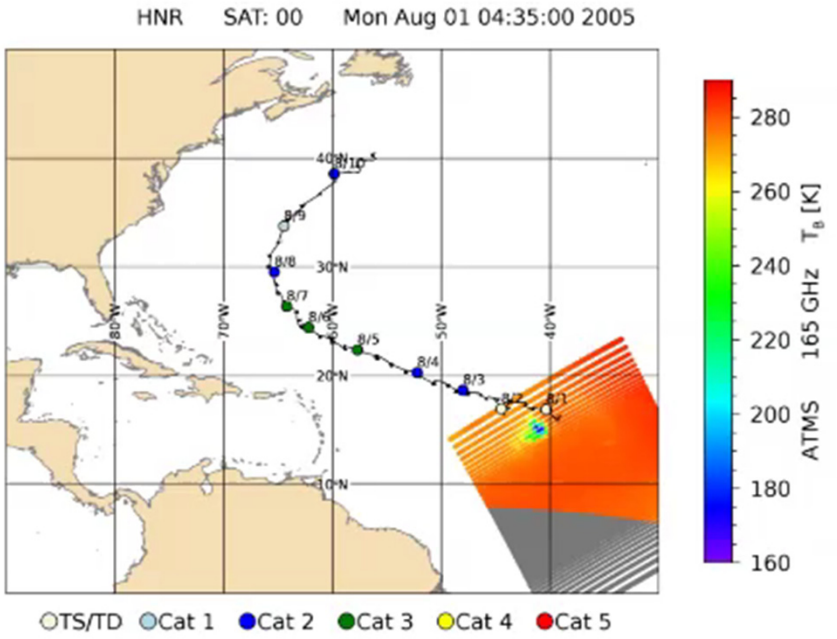
Description of the TROPICS Level-2a Data Product

Variable	Short Name	Dimensions	Data Type	Description	Units (Valid Range of Values)
All Level-1a Fields except the Earth Scene Antenna Temperatures (ESAntTemp)					
Native Earth Scene Brightness Temperatures	ESBriTemp	12 channels x EarthN x ScanN	32-bit float	The Planck blackbody equivalent brightness temperatures of the Earth scene measurements (same as Level-1b)	Kelvin (3-330)
Unified Earth Scene Brightness Temperatures	ESUniTemp	12 channels x EarthN x ScanN	32-bit float	Unified brightness temperatures of the Earth scene measurements (Chan. 9-12 match F-band, and Chan. 1-8 remain unchanged)	Kelvin (3-330)
Chan. 12 (205 GHz) Standard Deviation	RadVar	EarthN x ScanN	32-bit float	Standard Deviation of channel 12 (205-GHz with finest spatial resolution) within a F-band footprint using Backus-Gilbert weighting (See ATBD Sect. 6.3)	Kevin (0 - 1)

Preliminary: Subject to Change

HNR Proxy Data Science

- **Numerical Weather Prediction Model Output:**
  - **Hurricane Nature Run 1 (see backup slide)**
  - **Single low Cat. 4 Multi-domain Atlantic**
- **Community Radiative Transfer Model (CRTM)**
- **Cross-track spatial sampling using idealized antenna pattern**
- **Idealized Spectral Response (i.e., boxcar channel set)**
- **Temporal Response: Orbital Parameters with intra-plane phasing**



Description of HNR Proxy Releases

Release	Format	HNR/RTM	Spatial	Spectral	Orbit
1	Brightness temp. saved in any format	**HNR1**/CRTM/Expected NEdT	Simulated TROPICS scan with top-hat circular footprint based on F-band (25-km nadir)	TROPICS "as designed" and ATMS	N/A
~~2~~	~~Same as above~~	~~Same as above~~	~~Simulated TROPICS scan using band beamwidths~~	~~Same as above~~	~~Same as above~~
3	Same as above	Same as above	~~Same as above~~ Simulated TROPICS scan using band beamwidths	Same as above	Simulated TROPICS orbital parameters (2 x 2 x 2 at 30° Incl. & equal spacing)
4	TROPICS Level-1b data product	Same as above	Same as above	Same as above	Same as above
5	TROPICS Level-0 data	Same as above	Same as above	Same as above	Same as above

Logistics

- **Estimated readiness of Release 4 Proxy dataset and documentation: Late 2018 (after TROPICS CDR)**
- **TROPICS launch dates are still TBD, but estimated in 2020**
- **Data dissemination:**
  - **https://www.nsstc.uah.edu/tropics/**
  - **Will look into using GES DISC (same as post-launch)**

Backup Slides

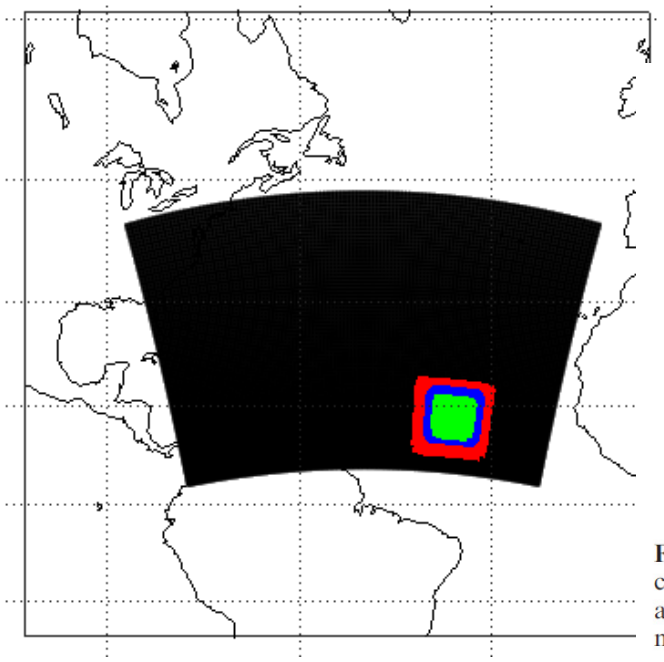
Hurricane WRF Nature Run 1

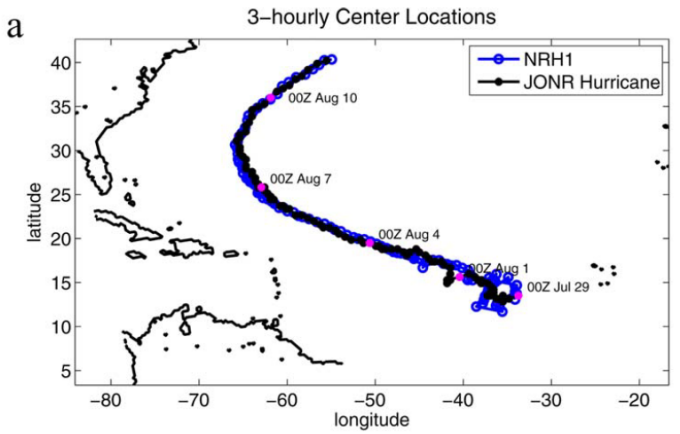
Black: D01 27-km Spacing (240 x 160 = 6000 km x 4000 km)

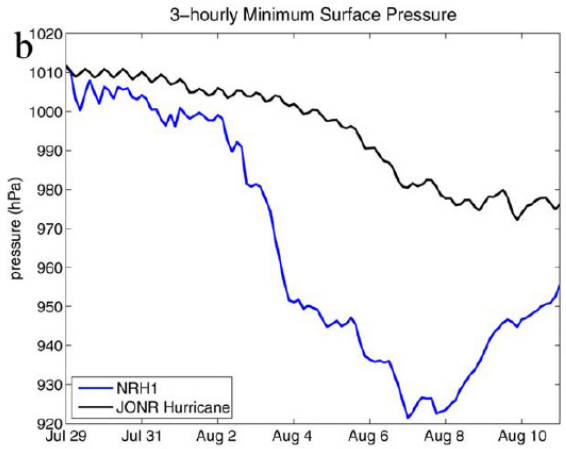
Red: D02 9-km Spacing (120 x 120 = 1044 km) Nested Grid

Blue: D03 3-km Spacing (240 x 240 = 700 km) Nested Grid

Green: D04 1-km Spacing (480 x 480 = 480 km) Nested Grid







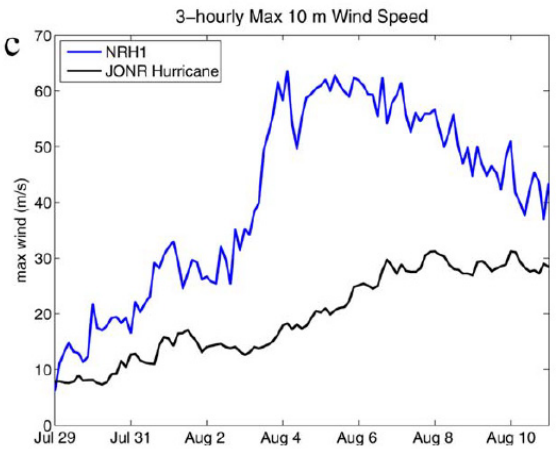


Figure 4. (a) Track, (b) minimum surface pressure, and (c) maximum surface (10 m) wind for the JONR hurricane and NRH1. Values are plotted every 3 h, and the data for the WRF nature run are from the 1 km grid, adjusted to 1 min means. Locations of the JONR hurricane corresponding to the dates shown are marked in magenta.

MIRS L2b AVTP & AVMP Output (1 of 2)

Parameter Name	Dimension	Data Type/ (Scale Factor)	Explanation
Atm_type	Scanline x Field_of_view	I*16	Atmospheric classification (currently missing)
ChiSqr	Scanline x Field_of_view	R*32	Convergence metric
Emis	Scanline x Field_of_view x Channel	I*16 (10000)	Surface emissivity vector
Freq	Channel	R*32	Instrument chan. central frequencies (GHz)
LZ_angle	Scanline x Field_of_view	R*32	Scene local zenith angle (degrees)
Latitude	Scanline x Field_of_view	R*32	Latitude (degrees)
Longitude	Scanline x Field_of_view	R*32	Longitude (degrees)
Orb_mode	Scanline x Field_of_view	I*16	0-ascending, 1-descending (orbit node)
PClw	Scanline x Field_of_view x P_Layer	R*32	Cloud liquid water profile (mm)
PGraupel	Scanline x Field_of_view x P_Layer	R*32	Graupel water profile (mm)
PIce	Scanline x Field_of_view x P_Layer	R*32	Cloud ice water profile (mm)
PRain	Scanline x Field_of_view x P_Layer	R*32	Rain water profile (mm)
PSnow	Scanline x Field_of_view x P_Layer	R*32	Snow water profile (mm)
Ptemp (AVTP)	Scanline x Field_of_view x P_Layer	R*32	Temperature Profile (K)
Pvapor (AVMP)	Scanline x Field_of_view x P_Layer	R*32	Water vapor profile (g/kg)

Caveat: TROPICS is only validating AVTP and AVMP. Other retrievals, if available, are best effort.

Source: MIRS ICD Table 30
https://www.star.nesdis.noaa.gov/mirs/documentation.php

MIRS L2b AVTP & AVMP Output (1 of 2)

Parameter Name	Dimension	Data Type/ (Scale Factor)	Explanation
Player	P_Layer	R*32	Pressure layer grid (hPa)
Plevel	P_Level	R*32	Pressure level grid (hPa)
Polo	Channel	I*16	Instrument chan. polarizations
Qc	Scanline x Field_of_view x Qc_dim	I*16	QC array: QC(0) 0-good, 1-use with caution, 2-bad
RAzi_angle	Scanline x Field_of_view	R*32	Relative Azimuth angle (degrees)
SZ_angle	Scanline x Field_of_view	R*32	Satellite Zenith angle (degrees)
ScanTime_UTC	Scanline x Field_of_view	R*64	Number of seconds since 00:00:00 UTC
ScanTime_dom	Scanline x Field_of_view	I*16	Scan time day of month
ScanTime_doy	Scanline x Field_of_view	I*16	Scan time day of year
ScanTime_hour	Scanline x Field_of_view	I*16	Scan time hour of day
ScanTime_minute	Scanline x Field_of_view	I*16	Scan time minute of hour
ScanTime_month	Scanline x Field_of_view	I*16	Scan time calendar month
ScanTime_second	Scanline x Field_of_view	I*16	Scan time second of minute
ScanTime_year	Scanline x Field_of_view	I*16	Scan time calendar year
Sfc_type	Scanline x Field_of_view	I*16	Surface classification
SurfP	Scanline x Field_of_view	I*16 (10)	Surface pressure value

Caveat: TROPICS is only validating AVTP and AVMP. Other retrievals, if available, are best effort.

Source: MIRS ICD Table 30
https://www.star.nesdis.noaa.gov/mirs/documentation.php