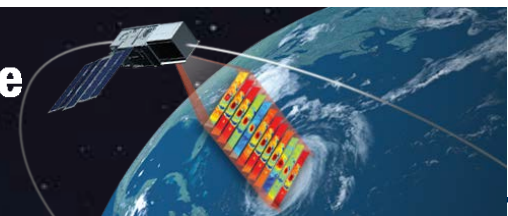




**Time-Resolved Observations of Precipitation structure
and storm Intensity with a Constellation of Smallsats**



Data Products and Proxy Data

TROPICS 2019Q2 Quarterly Applications Call

TROPICS Science Team

20 June 2019

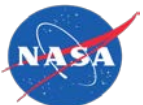
 **LINCOLN LABORATORY**
MASSACHUSETTS INSTITUTE OF TECHNOLOGY



Outline



- **TROPICS Payload Characterization**
- **CRTM Coefficient Update**
- **TROPICS Proxy Data Status**
- **Release Plan**





TROPICS Channel Set

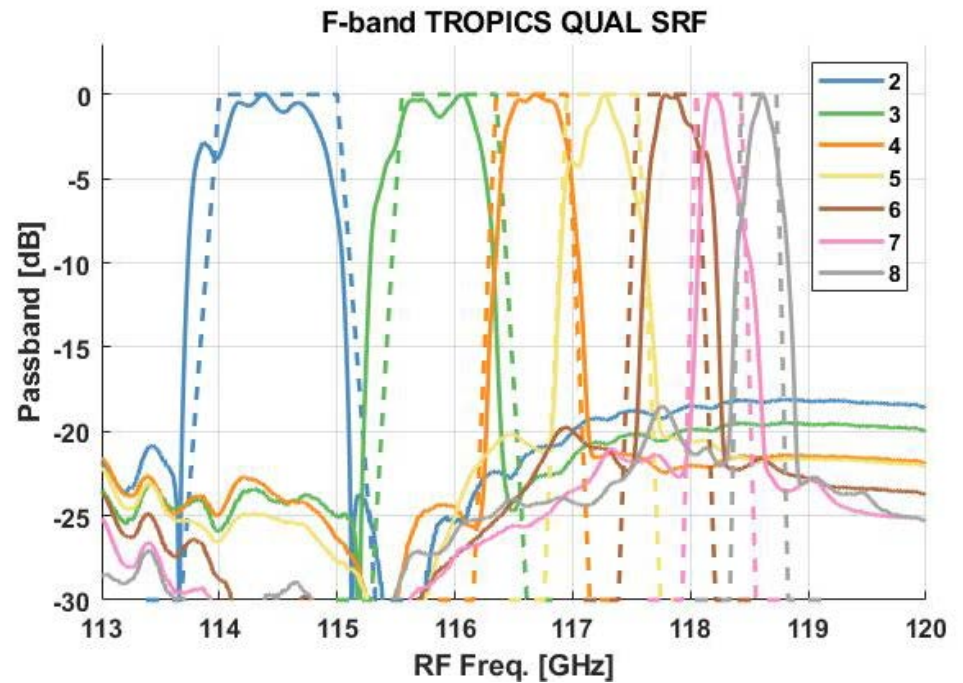
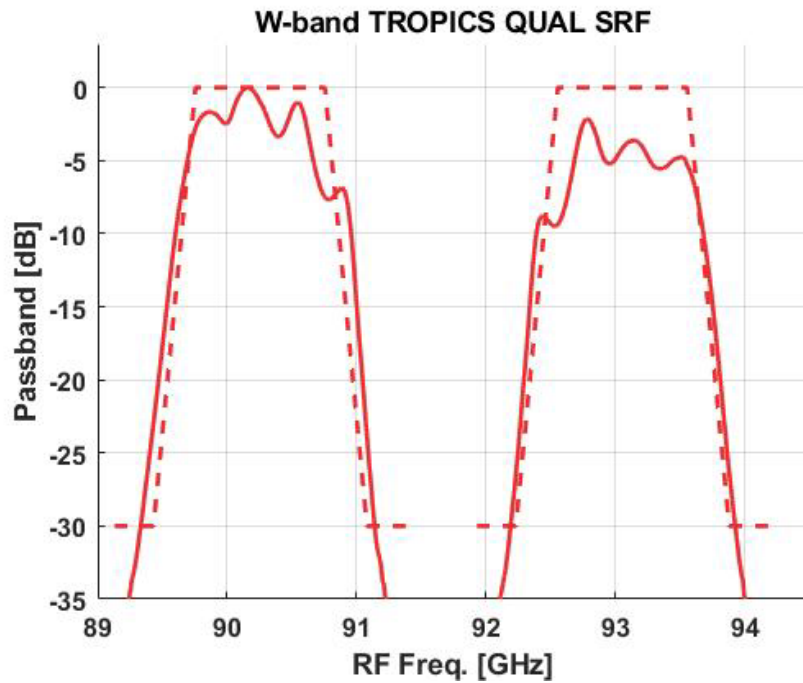


TROPICS Chan.	Center Freq. (GHz)	Bandwidth (GHz)	RF Span (GHz)	Beamwidth (degrees) Down/Cross	Nadir Footprint Geometric Mean (km)*	Expected NEdT (K)
1	91.656 ± 1.4	1.000	89.756-90.756, 92.556-93.556	3.0/3.17	29.6	0.7
2	114.50	1.000	114.00-115.00	2.4/2.62	24.1	1.0
3	115.95	0.800	115.55-116.35	2.4/2.62	24.1	0.9
4	116.65	0.600	116.35-116.95	2.4/2.62	24.1	0.9
5	117.25	0.600	116.95-117.55	2.4/2.62	24.1	0.9
6	117.80	0.500	117.55-118.05	2.4/2.62	24.1	0.9
7	118.24	0.380	118.05-118.43	2.4/2.62	24.1	0.9
8	118.58	0.300	118.43-118.73	2.4/2.62	24.1	1.0
9	184.41	2.000	183.41-185.41	1.5/1.87	16.1	0.7
10	186.51	2.000	185.51-187.51	1.5/1.87	16.1	0.7
11	190.31	2.000	189.31-191.31	1.5/1.87	16.1	0.7
12	204.8	2.000	203.8-205.8	1.45/1.83	15.6	0.7

WJ, Blackwell, Braun, S, Bennartz, R, et al. An overview of the TROPICS NASA Earth Venture Mission. *Q J R Meteorol Soc.* 2018; 144 (Suppl. 1): 16– 26. <https://doi.org/10.1002/qj.3290>

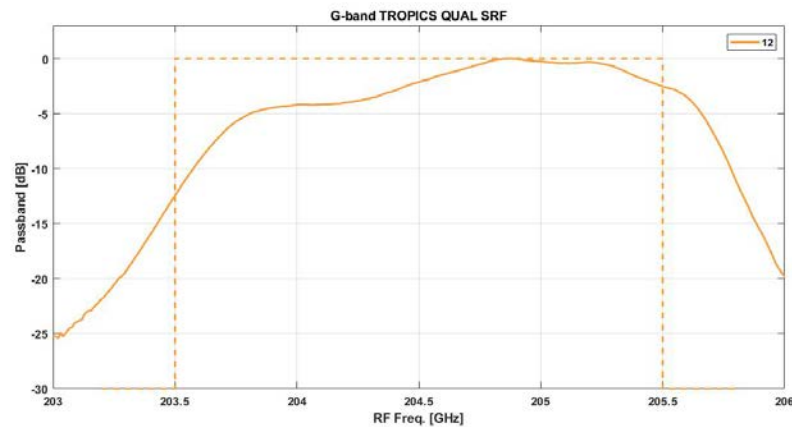
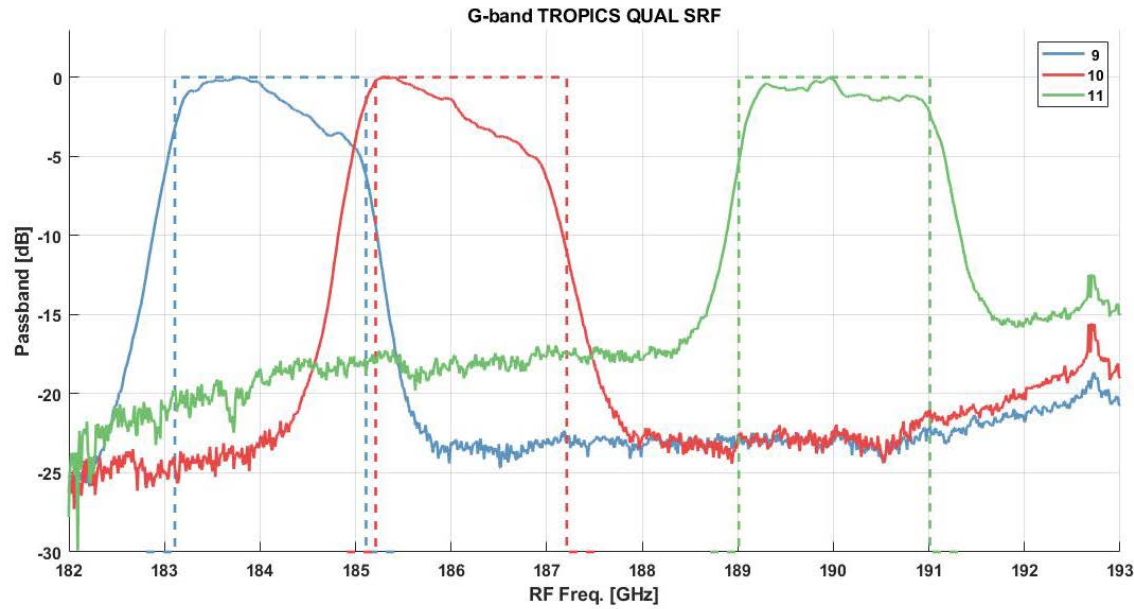


W/F-band Spectral Response





G-band Spectral Response





CRTM Status (1 of 2)



- **At this time, the only TROPICS CRTM coefficients available are the “as designed v1” that NOAA/Tong made in 9/2017 using idealized/boxcar passbands**
- **TROPICS will eventually have six “as built” CRTM coefficients for each Cubesat using that Cubesat’s measured Spectral Response Function (SRFs)**
- **The six TROPICS Cubesats are still being built and all of the SRFs haven’t been measured yet.**
- **Sometime this summer, LL will deliver the SRFs to David Bates at NOAA/AOML (Tong is working on other things) and he will make the as built CRTM coefficients for each CubeSat**
- **For now, any TROPICS studies should use the TROPICS “as designed” CRTM coefficients because Micromas-2 and TROPICS have different passbands (i.e., different channel sets)**



CRTM Status (2 of 2)



- **TROPICS has transmittance and spectral coefficient files:**
 - **tropics_designed_v1.SpcCoeff.bin-BigEndian**
 - **tropics_designed_v1.SpcCoeff.bin-LittleEndian**
 - **tropics_designed_v1.TauCoeff.bin-BigEndian**
 - **tropics_designed_v1.TauCoeff.bin-LittleEndian**

- **Ralf Bennartz and team used default CloudCoeff.bin for the HNR Proxy simulations**
 - **Has the maximum frequency of 190 GHz, so 205-GHz channel used scattering coefficient of 190 GHz**
 - **Ben Johnson plans to support TROPICS for the extra coefficients in “the near future.” (both cloud and emiss.)**



Proxy Data Set Objectives



- **Science Performance Requirement Verification (Technical Performance Measures)**
 - Level-2a Unified radiance variability and performance
 - Level-2b AVTP/AVMP
 - Level-2b ISRR
 - Level-2b TC Intensity

- **Testing Ground Segment**
 - Data format
 - Processing chain



Two Types of L1 Proxy Data Sets



A) Simulated HNR

- Hurricane Nature Run 1 (Nolan et al.) – single Cat. 4 TC over life cycle
- Community Radiative Transfer Model (CRTM)
- Simulated TROPICS spec. (along with simulated ATMS spectral)
- Mean Revisit Rate simulated through orbital parameters
- Final releases will be in final data format for ground segment testing
- All algorithms will use this proxy data for performance & checkout

B) FY-3C MWHS-2

- Actual 118- & 183-GHz TC measurements
- FY-3C MWHS-2 specifications (e.g., Horiz. Spatial Res.)
- Can simulate TROPICS by differencing MWHS-2 channels
- ~900 Cat 1-5 TC global overpasses from 2013 to 2017 (have ATMS overpasses to compare)
- Matched overpasses with ATCF hurricane database
- Primarily for TC intensity performance (TCIE)

MWHS-2 is for performance only (not ground segment)



Description of HNR Proxy Releases



Release	Format	HNR/RTM	Spatial	Spectral	Orbit
1	Brightness temp. saved in custom netCDF	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
3	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

Still tweaking data product format



Data Product Highlights



- **TROPICS is required to deliver data in netCDF4 format, but Emily 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**
- **Public documentation (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)



Logistics



- **Estimated readiness of L1 HNR proxy dataset (in TROPICS data format) & documentation is late Summer 2019**
- **L1 HNR proxy dataset in custom netcdf available now (Contact Prof. Ralf Bennartz ralf.bennartz@vanderbilt.edu)**
- **FY-3 MWHS-2 proxy dataset ready now (Contact Prof. Ralf Bennartz)**
- **TROPICS launch dates are still TBD (>2020)**
- **HNR Proxy Data dissemination:**
 - **<https://www.nsstc.uah.edu/tropics/>**
 - **Will look into using GES DISC (same as post-launch)**



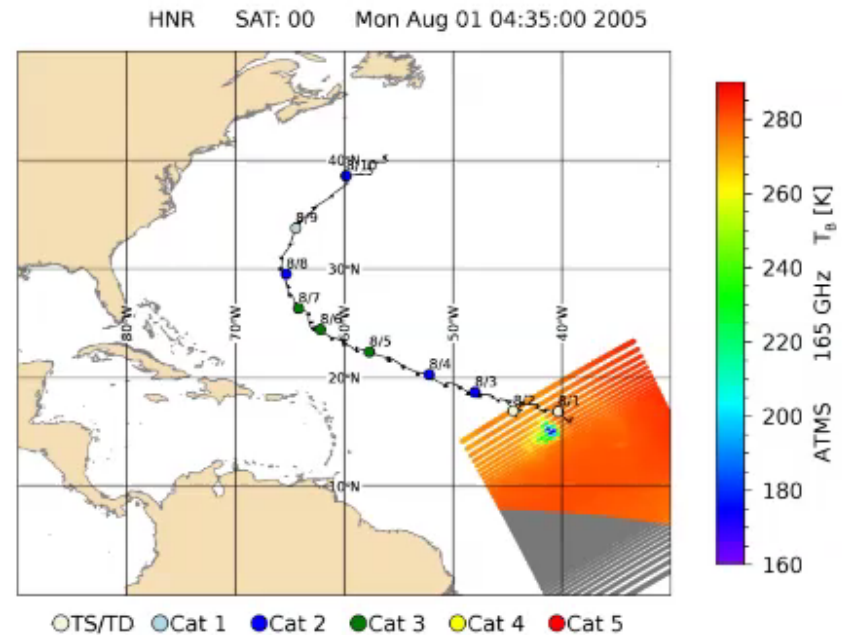
Backup Slides



HNR Proxy Data Science

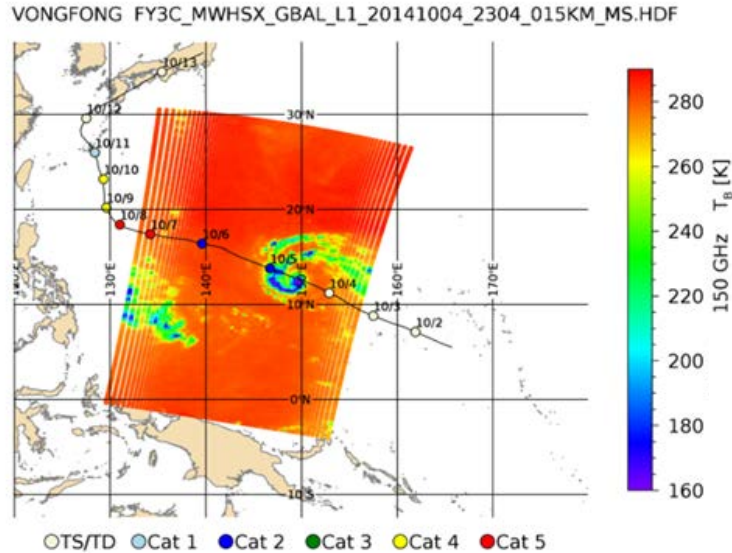


- **Numerical Weather Prediction Model Output:**
 - Hurricane Nature Run 1 (see backup slide)
 - Single low Cat. 4 Multi-domain Atlantic
- **Community Radiative Transfer Model (CRTM)**
- **Cross-track spatial sampling using idealized antenna pattern**
- **Idealized Spectral Response (i.e., boxcar channel set)**
- **Temporal Response: Orbital Parameters with intra-plane phasing**
- **Will provide all output (L1b to L2b)**

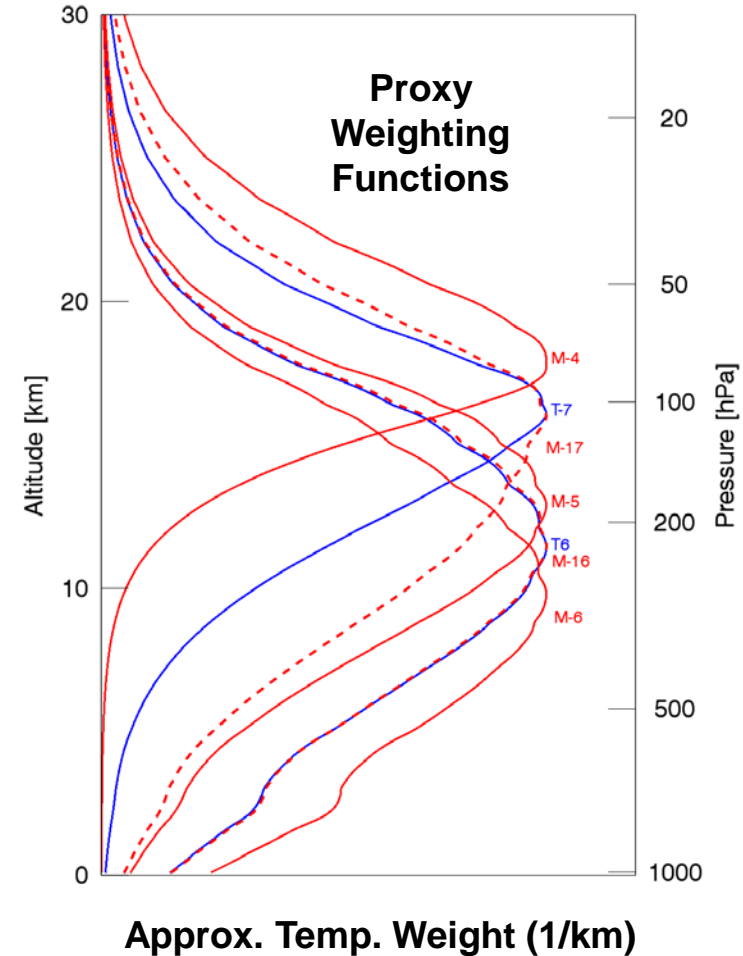




FY-3C/MWHS-2 Proxy Data Set



- **TC Intensity F-band channels:**
 - TROPICS 6 = (CH5+CH6)/2 of MWHS-2.
 - TROPICS 7 = (CH4+CH5)/2 of MWHS-2.
- **WV channels:**
 - TROPICS 11 uses MWHS 15
 - TROPICS 10 uses MWHS 14
 - TROPICS 9 uses MWHS 11





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)
Level 1a	Timestamped, geolocated, calibrated antenna temperature	Vince Leslie (LL)
Level 1b	Timestamped, geolocated, calibrated brightness temperature with bias removed	Vince Leslie (LL)
Level 2a	Spatially resampled (i.e., collocated) G-band brightness temperature (to F-band resolution)	Ralf Bennartz (UWisc-Madison/Vanderbilt)
Level 2b MIRS { GPROF TCIE & HISA	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]	Toshihisa Matsui & Chris Kidd
	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



Hurricane WRF Nature Run 1



NOLAN ET AL.: DEVELOPMENT OF A HURRICANE NATURE RUN

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

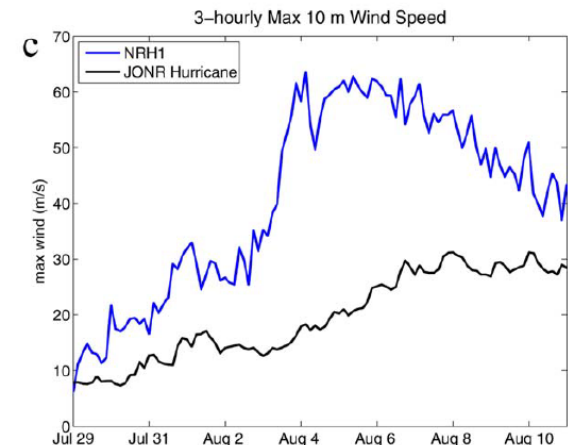
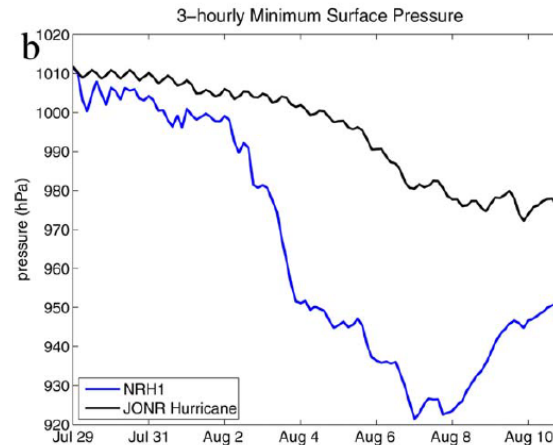
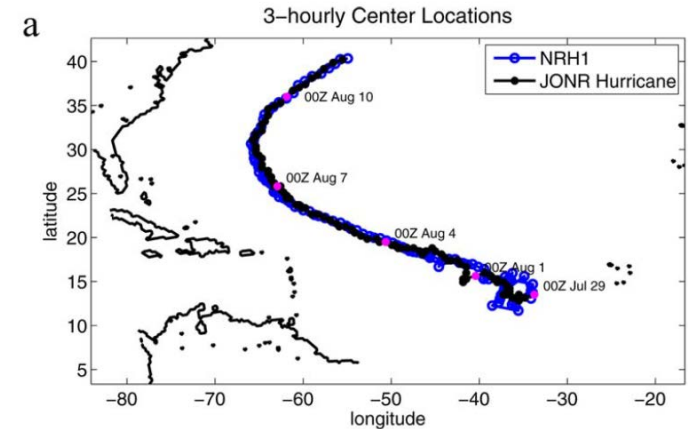


Figure 4. (a) Track, (b) minimum surface pressure, and (c) maximum surface (10 m) wind for the JONR hurricane and NRH1. Values are plotted every 3 h, and the data for the WRF nature run are from the 1 km grid, adjusted to 1 min means. Locations of the JONR hurricane corresponding to the dates shown are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



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.