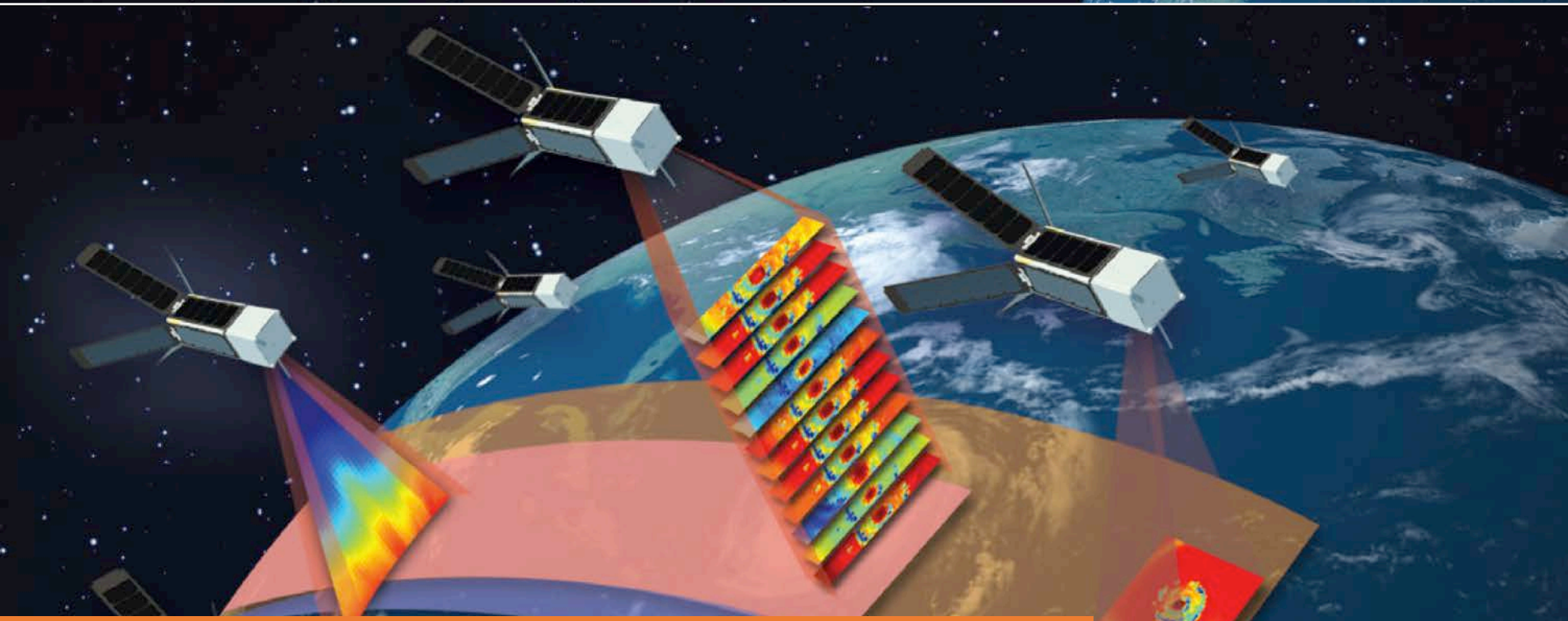
Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats

MIT Lincoln Laboratory (proposing organization)

William J. Blackwell, Principal Investigator, Scott Braun (NASA GSFC), Project Scientist



Science Team Members:
Robert Rogers, Robert Atlas, Frank Marks, Jason Dunion, NOAA/HRD
Mark DeMaria, NOAA/NHC
Chris Velden, U. Wisc.
Ralph Bennartz, Vanderbilt U.

Tropical Cyclone Operations and Research Forum
March 13-16, 2017

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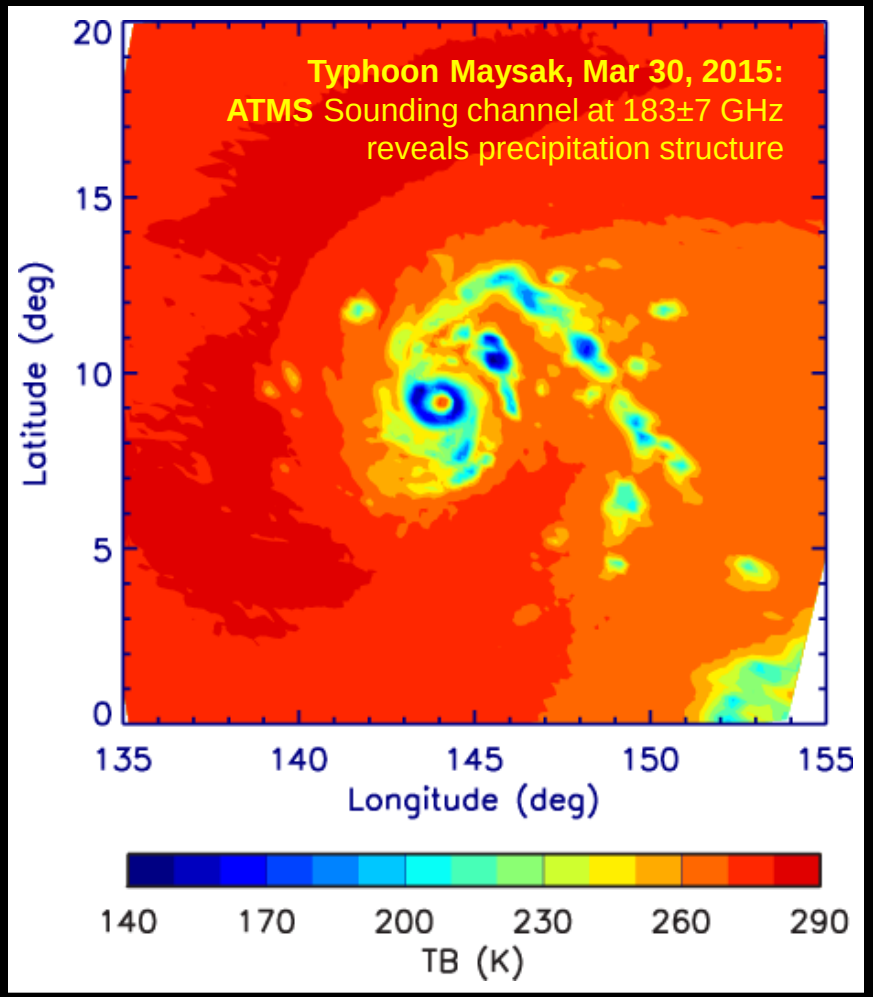
Broad Mission Overview

- First demonstration that science payloads on low-cost CubeSats can push the frontiers of spaceborne monitoring for Earth system science.
- TROPICS will fill gaps in our knowledge of the short-time scale—hourly or less—evolution of TCs. Current capabilities are an order of magnitude slower.
- TROPICS will complement CYGNSS, GPM, and GOES-16 by making rapid-refresh, direct measurements of temperature, humidity, and precipitation



https://tropics.ll.mit.edu

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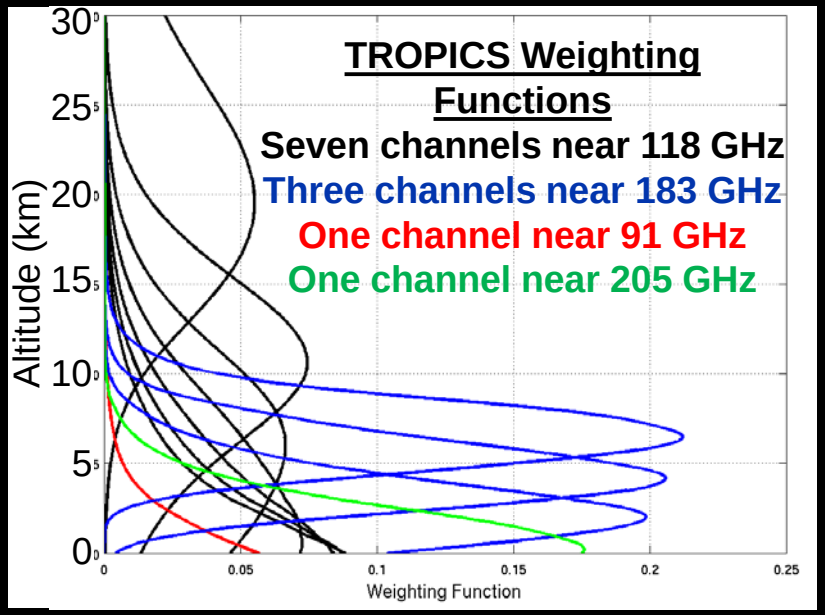
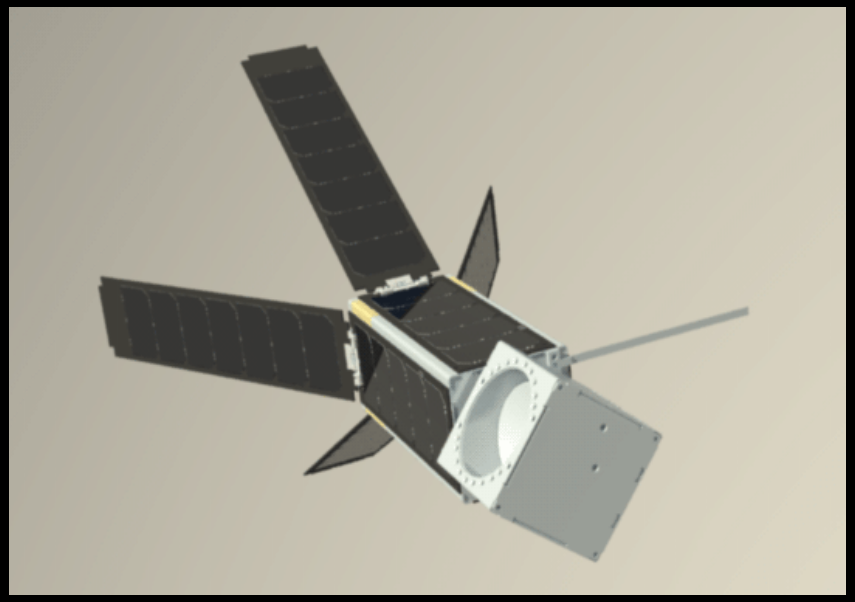
CubeSat and Radiometer

12-channel passive microwave radiometer

- **91 & 205 GHz imaging channels**
- **Temperature sounding near 118 GHz**
- **Moisture sounding near 183 GHz**





3U CubeSat, with 2U spacecraft bus, 1U radiometer, and deployed solar arrays

Spacecraft size (ignoring deployed solar panel size)
10 cm × 10 cm × 34 cm

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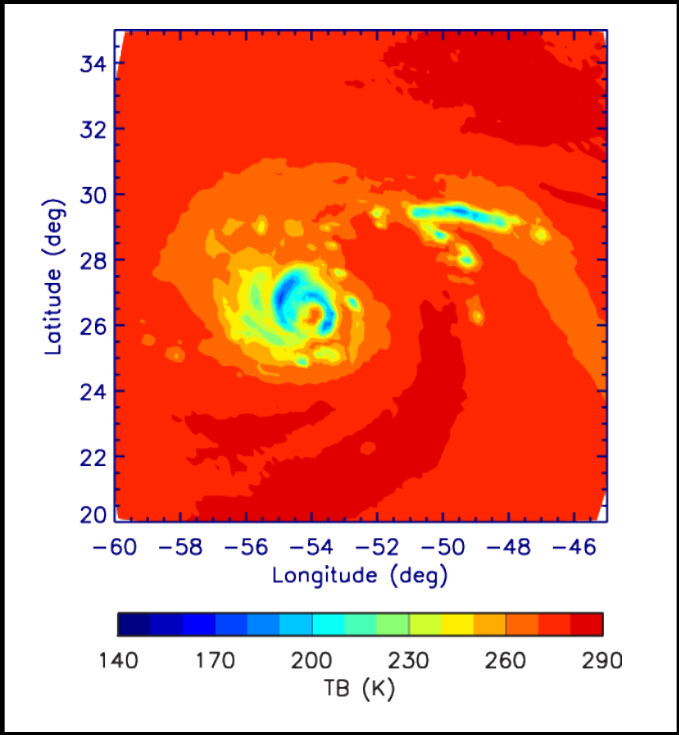
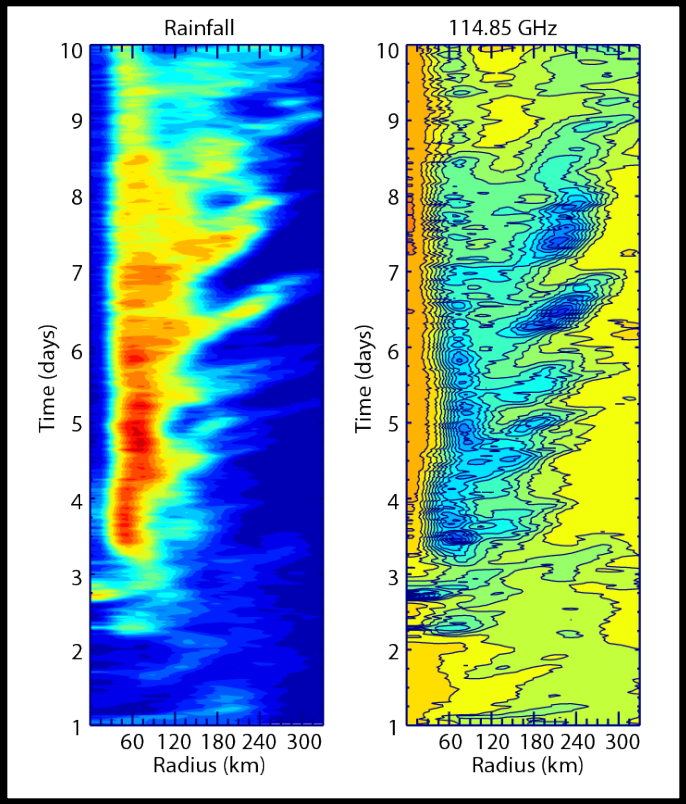
How does precipitation structure evolution, including diurnal cycle, relate to the evolution of the upper-level warm core and associated intensity changes?



How does the occurrence of intense precipitation cores (convective bursts) relate to storm intensity evolution?



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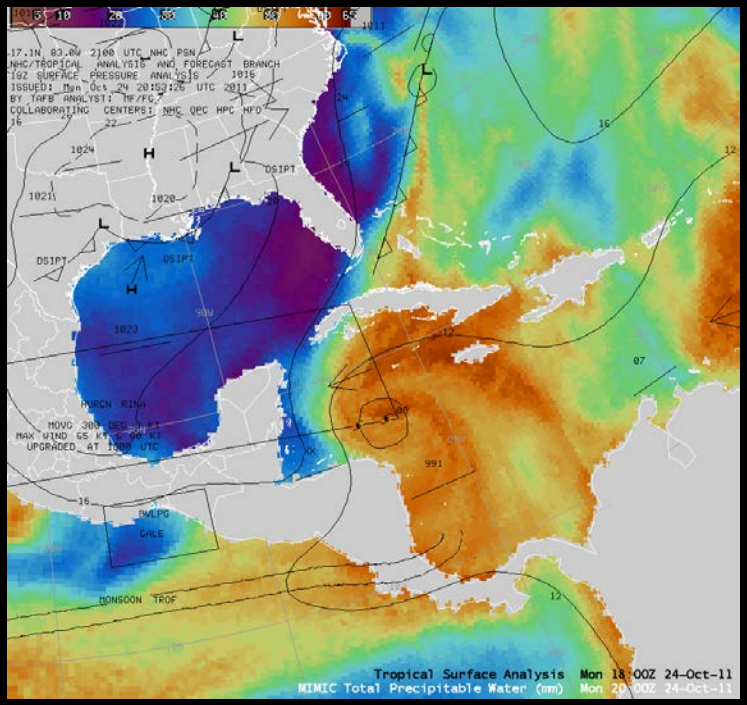
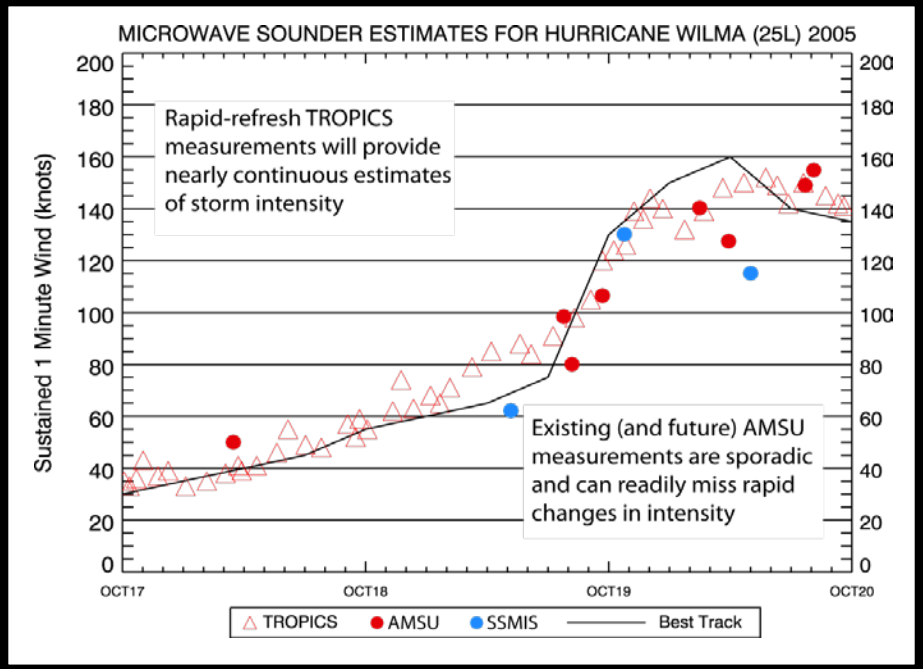
How does environmental moisture relate to coincident measures of storm structure (including size) and intensity?





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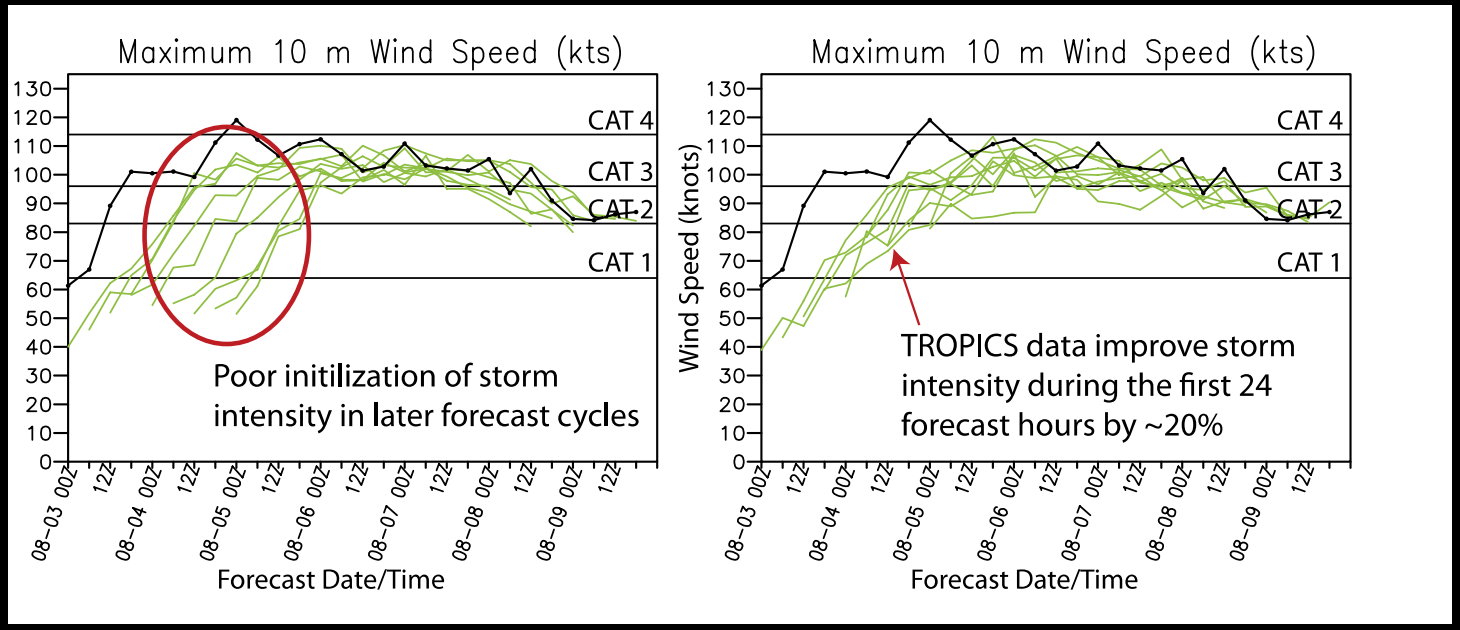
What will be the impact of microwave radiances and/or retrievals on numerical and statistical model predictions of storm track and intensity?



MODELS

NWP:
HWRF
GFS
GEOS-5

Statistical:
SHIPS

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TROPICS Pathfinders: MicroMAS-1, MicroMAS-2, and MiRaTA

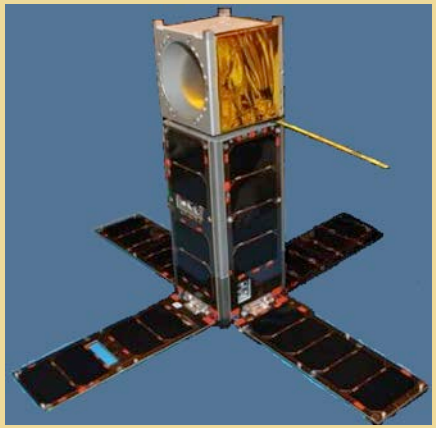
MicroMAS = Microsized Microwave Atmospheric Satellite
MiRaTA = Microwave Radiometer Technology Acceleration

MicroMAS-1

3U cubesat with 118-GHz radiometer

8 channels for temperature measurements

July 2014 launch, March 2015 release; validation of spacecraft systems; eventual transmitter failure

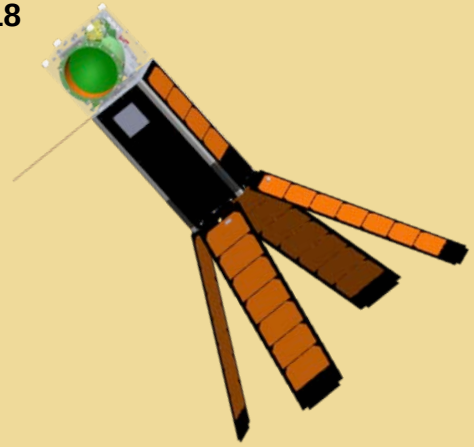


MicroMAS-2

3U cubesat scanning radiometer with channels near 90, 118, 183, and 206 GHz

12 channels for moisture and temperature profiling and precipitation imaging

Two launches in mid 2017/early 2018

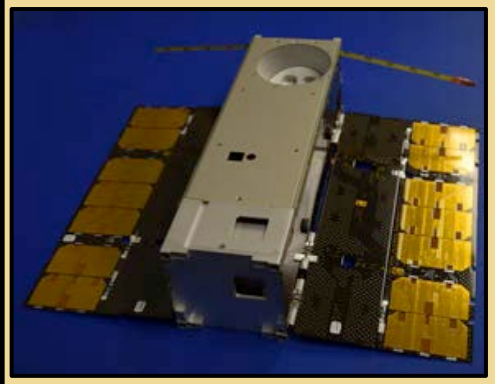


MiRaTA

3U cubesat with 60, 183, and 206 GHz radiometers and GPS radio occultation

10 channels for temperature, moisture, and cloud ice measurements

Launch on JPSS-1



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Spatial and Temporal Resolution

	ATMS Nadir/Avg (km)	TROPICS Nadir/Avg (km)
Temperature	33/44	27/40
Moisture & Precipitation	17/24	17/24
Swath width	2250 (±50.5°)	2025 (±56°)

TROPICS resolution comparable to ATMS

TROPICS will provide frequent revisits

	Average (min)	Median (min)
12 satellites	40	25
9 satellites	60	40
6 satellites	75	50

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Constellation Configuration

CubeSats in 3 orbital planes

Altitude of ~550 km, 30° inclination

Sweet spot between revisit rate and spatial resolution

Launch in late 2019, 1-year science operations

Orbit swaths for full constellation of 12

TROPICS coverage over past 30 minutes, updated every 15 minutes

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Baseline Science Data Products

L1 Data Products: Calibrated brightness temperatures

L2 Data Products

- Retrieved temperature and humidity profiles
- Precipitation/convection indicators
  - Scattering Index
  - Rain rates
- Storm intensity estimates (U. Wisc.)

Preliminary Data Volume Estimate

Total mission data (L0-L2):
~43 GB/day per satellite
~15-20 TB mission data per satellite over lifetime

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Requirements and Expected Performance

Product	Threshold Requirement (Uncertainty)	Baseline Requirement (Uncertainty)	Expected Performance (Uncertainty)
Temperature Profile	2.5 K*	2.0 K*	1.6 K
Moisture Profile	35%*	25%*	16%
Rain Rate	50%#	25%#	25%
Min. Sea-level Pressure	12 hPa	10 hPa	8 hPa
Max. Sustained Wind	8 m s^{-1}	6 m s^{-1}	6 m s^{-1}

*** Over 3 –km layers**

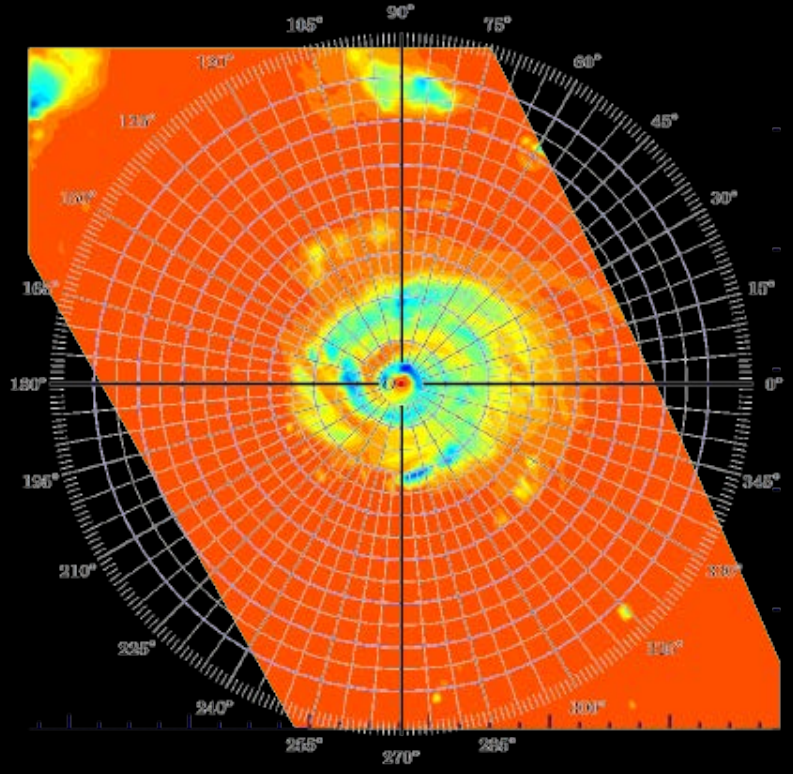
#Relative to GPM IMERG product

Potential Science Data Products

L2 Data Products—Storm centric products (being considered)

L3 Data Products—Gridded products

- Uniform spatial grid
- Gridding time interval TBD



Ground System and Data Latency

Data Acquisition latency
- <2 hours 50% of time
- <1 day almost all of the time

Ground system latency: Up to 6 hours for data processing (L0-L2)

Ground Station Network	Mission Operations Center	Science Operations Center	Data Processing Center
TBD	TBD	MIT LL	UW-SSEC
			
• Antenna commanding • Data demodulation • Temporary data storage	• Antenna commanding • SV Command & Control • Health and Status monitoring • Anomaly resolution	• Payload Monitoring • Payload long-term trending • Commanding support	• Data Processing (Lvl 0 to Lvl 2b) • Data formatting & archiving • Web Interface

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1st TROPICS Applications Workshop

- May 8-10, 2017
- Rosenstiel School of Marine & Atmos. Sci., University of Miami

http://tropics.ccs.miami.edu/

Meeting Objectives

- Introduce end-users to expected value of TROPICS by reviewing mission specifications and status
- Provide a forum for applied researchers and operational decision makers to share insight into how observations from TROPICS can be used in their organizations
- Establish an early adopter community to accelerate post-launch applications through access to TROPICS mission scientists and proxy datasets

Sponsored by the NASA Applied Science Program

For more information, contact brad.zavodsky@nasa.gov or jason.dunion@noaa.gov

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Questions?

Examples of ATMS 183±7 GHz Brightness Temperatures

Edouard (2014, ATL) | **Maysak (2015, WPAC)** | **Patricia (2015, EPAC)**