



J9.3. The NOAA NESDIS Microwave Sounder Pilot Project

106th Annual Meeting of the
American Meteorological Society

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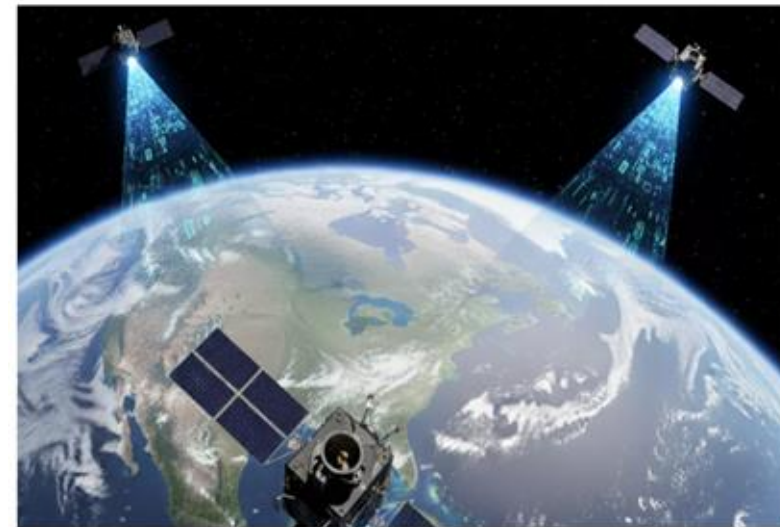
National Environmental Satellite,
Data, and Information Service

January 28, 2026

1. Science and Technology Corporation (supporting NESDIS SAE)
2. NOAA/NESDIS Systems Architecture & Engineering (SAE)
3. NOAA/Center for Satellite Applications and Research
4. Cooperative Institute for Meteorological Satellite Studies
5. Cooperative Institute for Research in the Atmosphere
6. Joint Center for Satellite Data Assimilation
7. University Corporation for Atmospheric Research

NESDIS CDP Commercial Data Pilots

- ❑ Assesses commercial satellite data to help improve weather forecasts and provide risk reduction to the observing system
 - Fills gaps, diversifies sources, adds low-cost redundancy
- ❑ The Microwave Sounder (MWS) Pilot is part of the Commercial Data Pilot series
 - Flexible orbital and constellations providing higher spatial/temporal coverage
 - Cross-community coordination evaluates data readiness, value, and operational viability
 - Results inform NOAA's future MWS architecture and strengthen forecasting performance



Why is NESDIS Piloting MWS Data

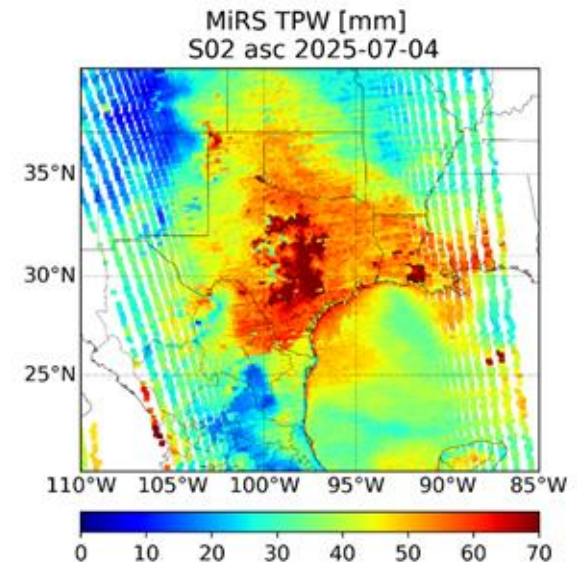
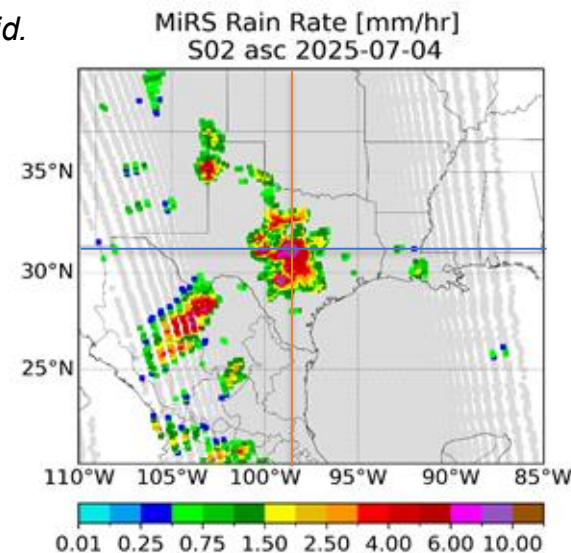
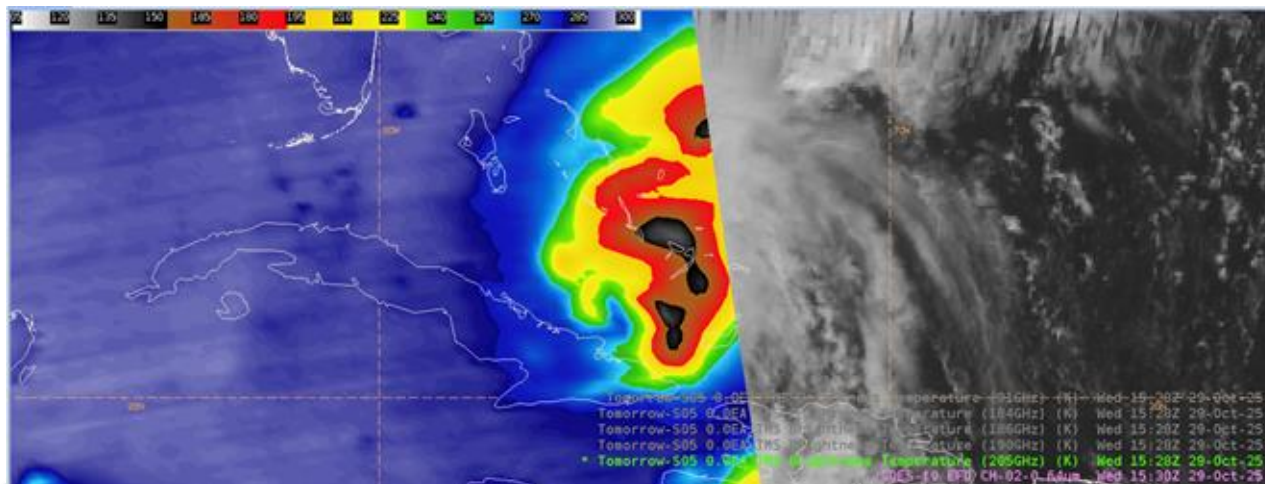
- *MW Are Uniquely Important for Earth Observing - Can See through Clouds*
- *Commercial data enables faster, more frequent weather observations.*

- ❑ **Strategic Value:** Enhances resilience, agility, cost-efficiency.
- ❑ **Operational Impact:** Major contributor to NWP, higher temporal resolution, fills backbone gaps
- ❑ **Innovation & Integration:** Early access to new technology & performance across orbits
- ❑ **Expected Outcomes:** Improves coverage and refresh rates, supports forecasts

Data Source: Tomorrow.io TMS

Texas Flash Flood 2025-07-04 04:55 UTC

BT for Melissa 10/29/25 in NWS OST AWIPS, 15:28 Z; GOES-19 0.64 μ m 15:30 Z underlaid.



MWS Data Pilot & Collaboration Teams

Internal NOAA



**National Environmental Satellite,
Data, and Information Service**

DEPARTMENT OF COMMERCE



National Centers for Environmental Prediction
Environmental Modeling Center (EMC)

NATIONAL HURRICANE CENTER and
CENTRAL PACIFIC HURRICANE CENTER

**Office of Low
Earth Orbit (LEO)
Observations**



Domestic



**Cooperative Institute for Research
in the Atmosphere**



**Cooperative Institute for Meteorological
Satellite Studies**
University of Wisconsin-Madison



International



**National Research
Council (Italy)**



MWS Data Pilot Overview

❑ Data:

- Data purchase: two satellite worth data from Tomorrow.io, mixed & match
- Data delivery: NRT 9.5 months (Feb. 18 – Dec 2, 2025)
- Data sharing: research use, free to government and WMO partners, no commercial use

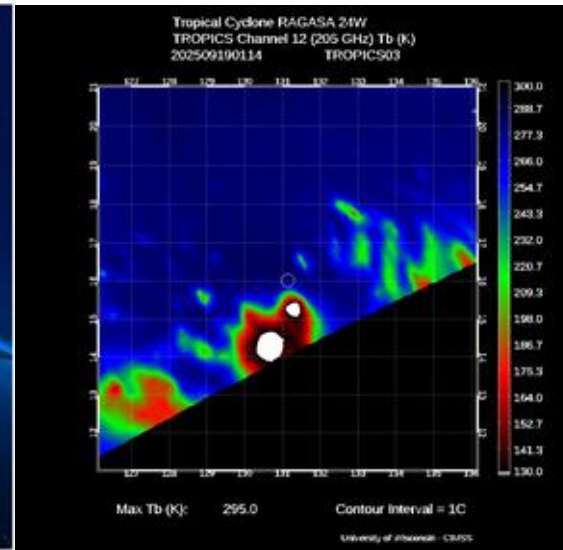
❑ Evaluation and Technical Considerations:

- Assess data quality via Cal/Val. and validate geophysics parameters
- Quantify data assimilation and impact on NWP performance
- Operational readiness and complementary to government backbone

Space vehicle	Launch date	Orbit	Deployment Altitude
Tomorrow-S1	16 Aug 2024	SSO (2239 LTAN)	515 x 510 km
Tomorrow-S2	16 Aug 2024	SSO (2239 LTAN)	515 x 510 km
Tomorrow-S3	21 Dec 2024	45° (71.27° RAAN)	525 x 508 km
Tomorrow-S4	21 Dec 2024	45° (71.21° RAAN)	526 x 508 km
Tomorrow-S5	14 Mar 2025	SSO (1026 LTAN)	521 x 508 km
Tomorrow-S6	14 Mar 2025	SSO (1026 LTAN)	518 x 507 km
Tomorrow-S7	21 Apr 2025	45° (120.46° RAAN)	580 x 570 km



Tomorrow.io MWS sensor cross-track scan. Image from <https://www.tomorrow.io/space/sounder/>.



Combined observation from TROPICS and Tomorrow.io for Typhoon Ragasa from CIMSS

Tomorrow.io Microwave Sounder (TMS) Capabilities

❑ Science Community Needs

- Direct temp. and moisture sounding channels
- ATMS equivalent performance
- Secondary 118 GHz for temperature sounding
- Inter-calibration
- Hyperspectral capability

❑ Current **Tomorrow.io** TMS Capabilities

- Bands (GHz) - 91, 114-122, 184, 186, 189, 204
- Baseline vertical profiling similar to ATMS moisture and TROPICS temp. sounding channels
- Strong moisture sounding capability
- 3-year design life
- Higher temporal resolution and revisit rate

Band	JPSS/ ATMS	Metop-SG /MWS	NEON/ SMBA	EPS- Sterna	Tomorrow.i o & TROPICS
K - 23.8 GHz (Ice, Cloud, Precipitation, Surface imagery)	X	X	X (HS)		
Ka - 31.4 GHz (Precipitation Window)	X	X	X (HS)		
V - 50-60 GHz (Temperature Profile)	X	X	X (HS)	X	
W - 88.2 GHz, 91.65 GHz (Surface Window, Precipitation)	X	X	X	X	X
F - 114-118 GHz (Temperature - experimental alternative to 50-60 GHz)			X (HS)		X
D - 165 GHz (Surface Window, Precipitation)	X	X	X		
G - 183.31 GHz (Moisture/ Humidity Profile)	X	X	X (HS)	X	X
J - 204 GHz (Ice and Cloud - experimental alternative to 165 GHz)		X	X	X (325Ghz)	X



What We Are Piloting

❑ Primary Objectives (Direct Measurements)

- Atmospheric Vertical Temperature Profile – All-weather capability
- Atmospheric Vertical Moisture Profile (AVMP) – All-weather

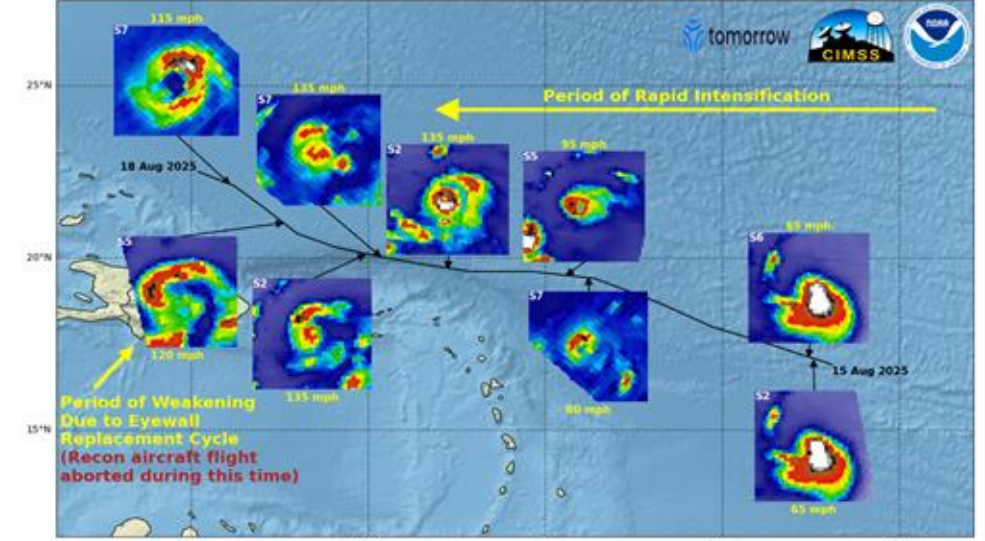
❑ Contributing Objectives (Derived Products)

- MiRS (Microwave Integrated Retrieval System) NRT L2 data
- Downstream data products:
 - Tropical Cyclone intensity and imagery
 - bTPW & ALPW

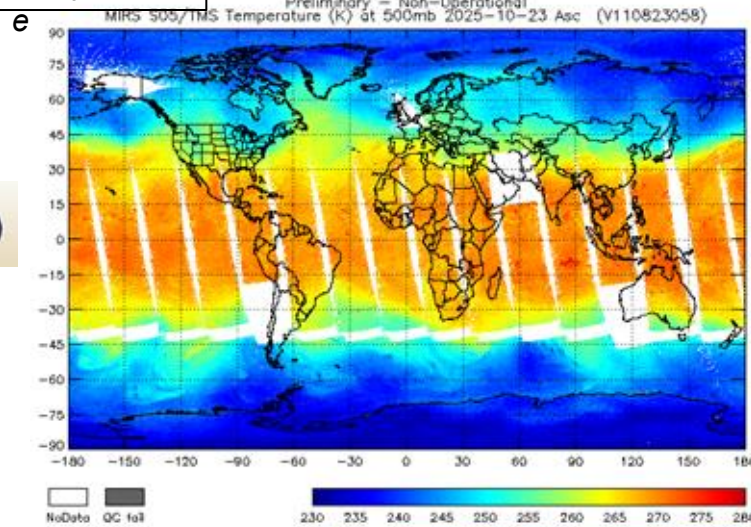
❑ NWP Applications

- Global Forecast System (GFS) Model Impact studies

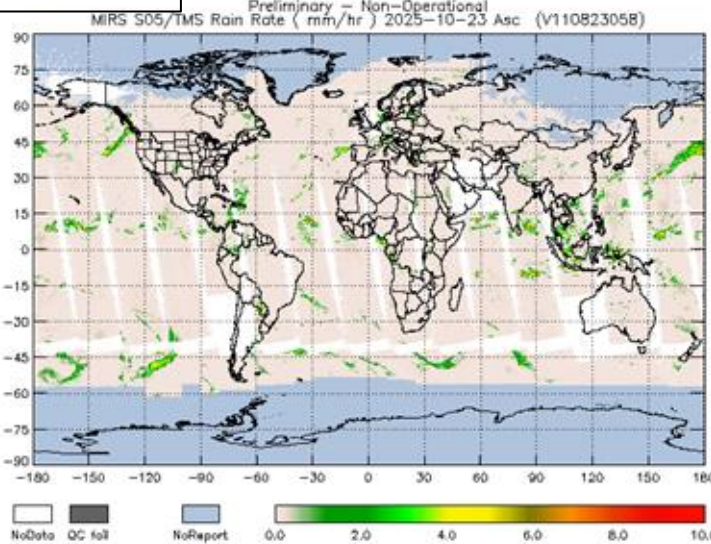
Estimates of Maximum Winds in Hurricane Erin from Tomorrow.io Satellites (S2-S7) using AI Methods



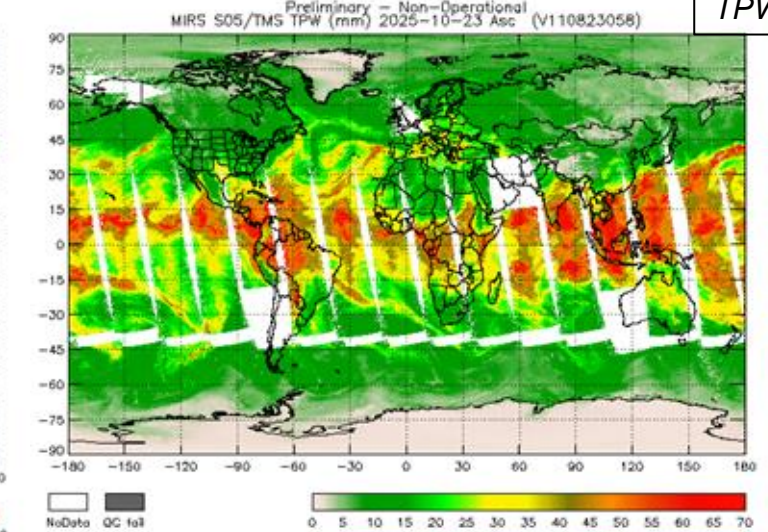
Temperature



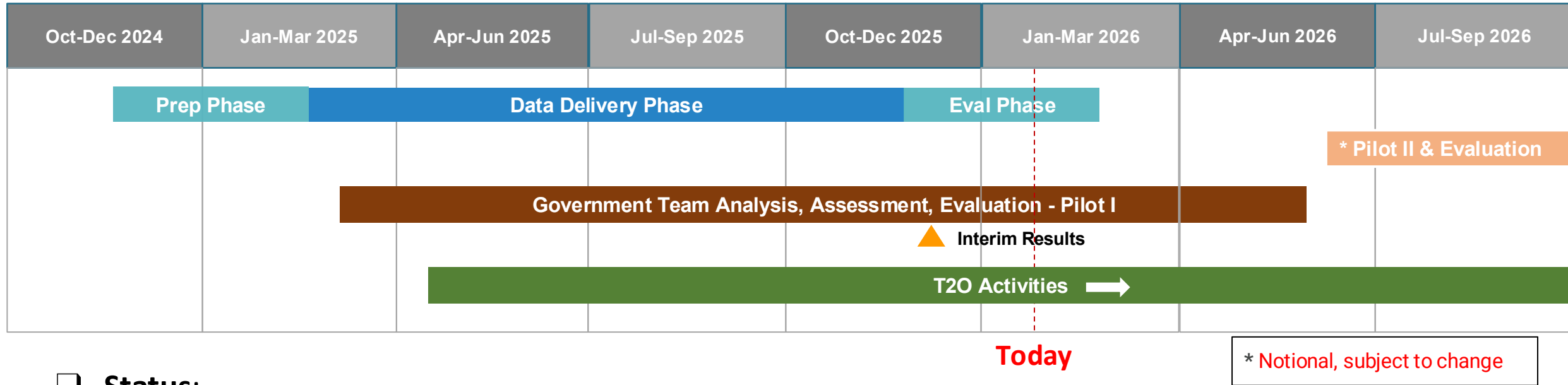
Rain Rate



TPW



MWS Pilot-I Timeline & Status



❑ Status:

- Initial demonstration of Tomorrow.io MWS capabilities for NOAA applications.
- Calibration focused on radiometric accuracy, noise, and geophysical performance is now complete.
- End-to-end data analysis focusing on refining algorithms for best operational practices, including AI methods to prepare for ops.
- Performance limitations were identified but are improving; ongoing assessment includes EMC impact analysis.

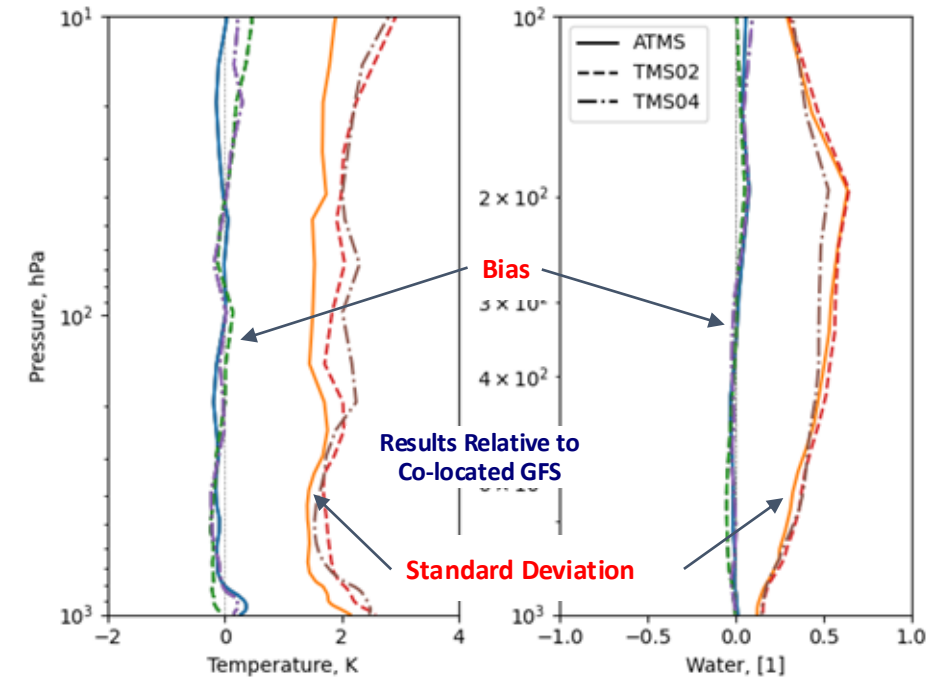
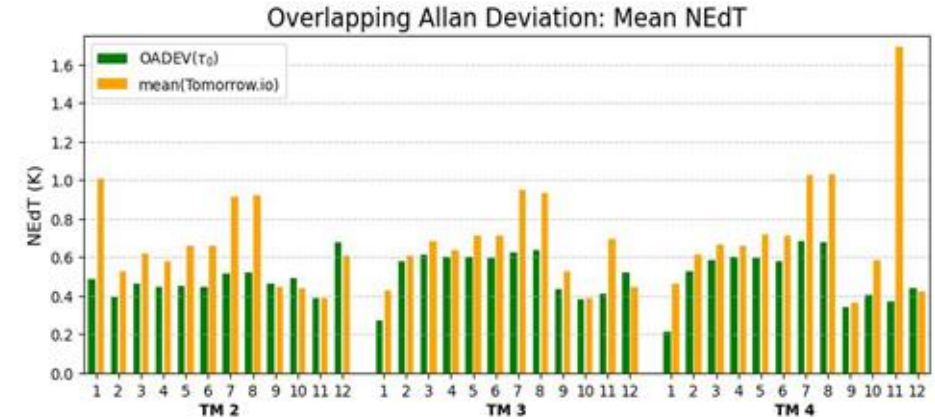
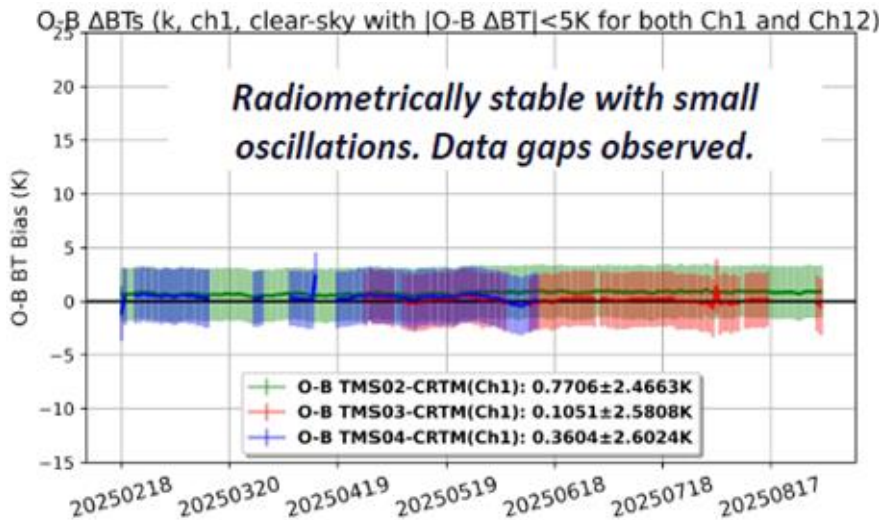
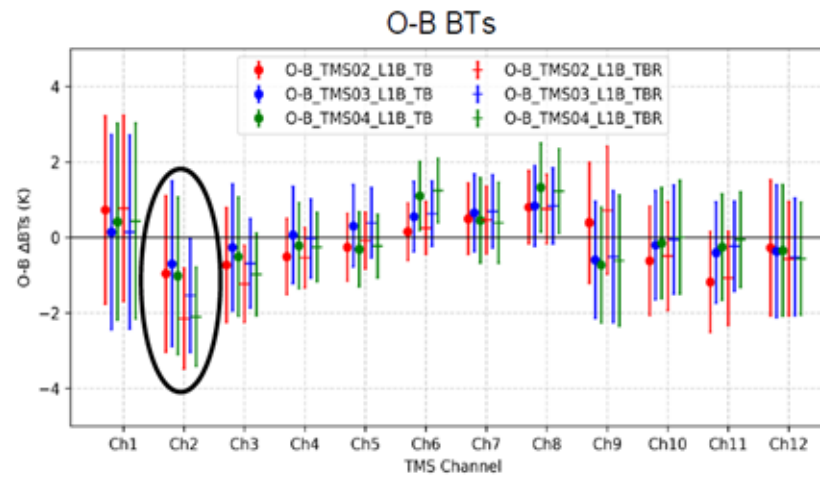
❑ Milestones:

- December 2025: Interim pilot results complete
- [Notional] June 2026: Pilot I final results



Cal/Val Evaluation

- ❑ Radiometric quality indicates Tomorrow.io data may be suitable for NOAA operational integration
- ❑ Allan Deviation-based noise estimates generally showing well-characterized sensor noise
- ❑ Geophysical assessment enhanced with MIIDAPS-AI* models, found valuable information for tropospheric weather forecasting, including:
 - Short-range forecasting
 - Storm tracking
 - Moisture transport monitoring

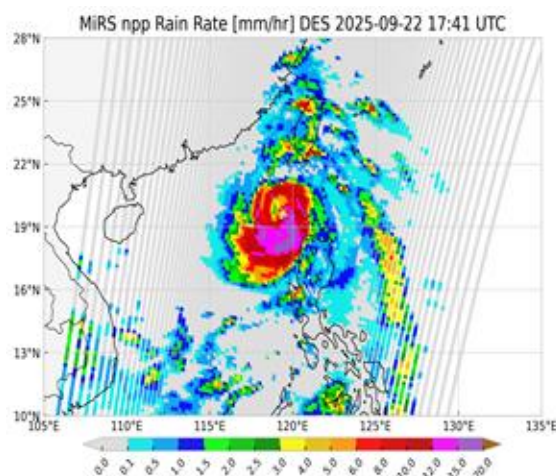
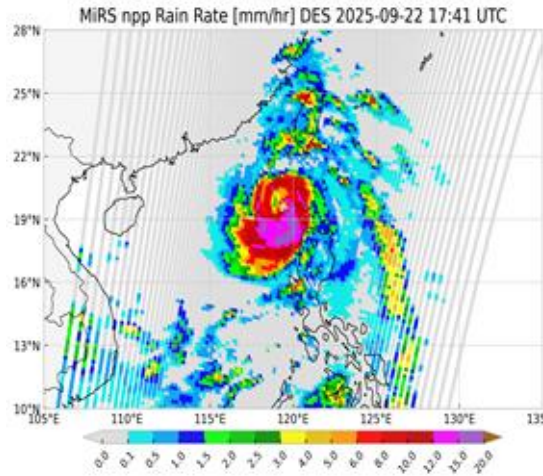


MIIDAPS-AI: The multi-instrument inversion and data assimilation preprocessing system, artificial intelligence version

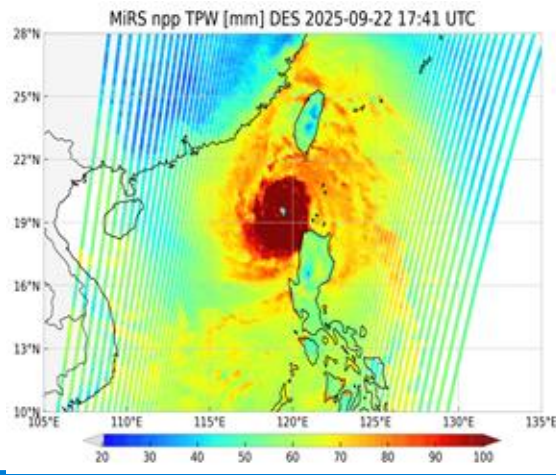
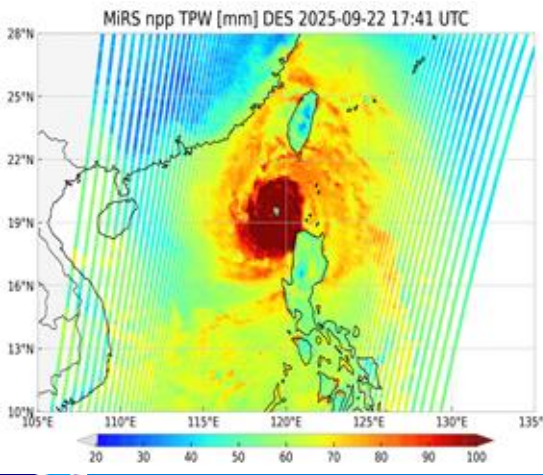
Rain rate -Typhoon Ragasa on September 22-23, 2025

Without Tomorrow.io

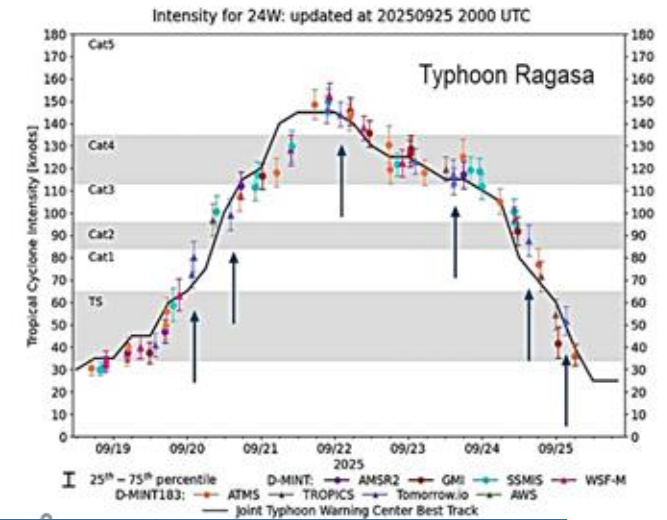
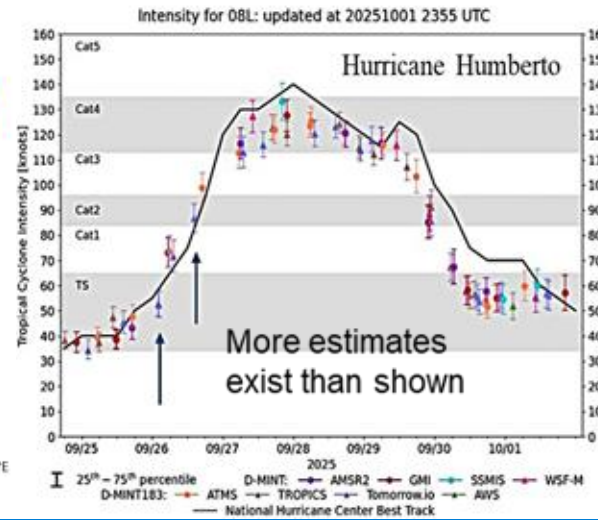
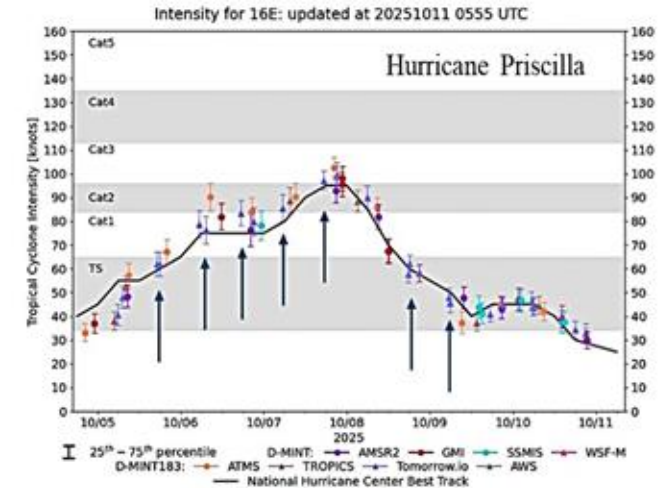
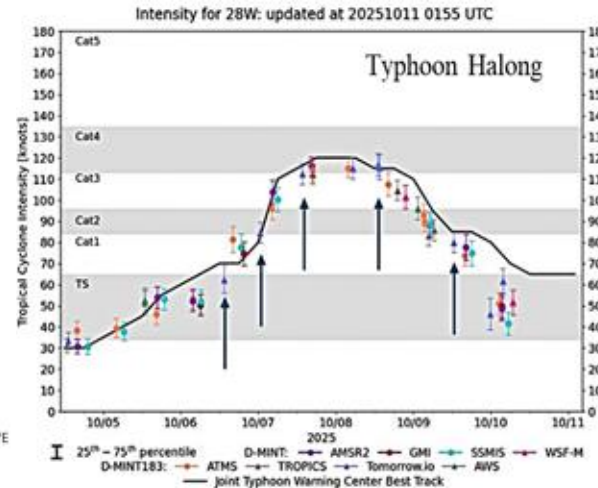
With Tomorrow.io (s02, s05, s06)



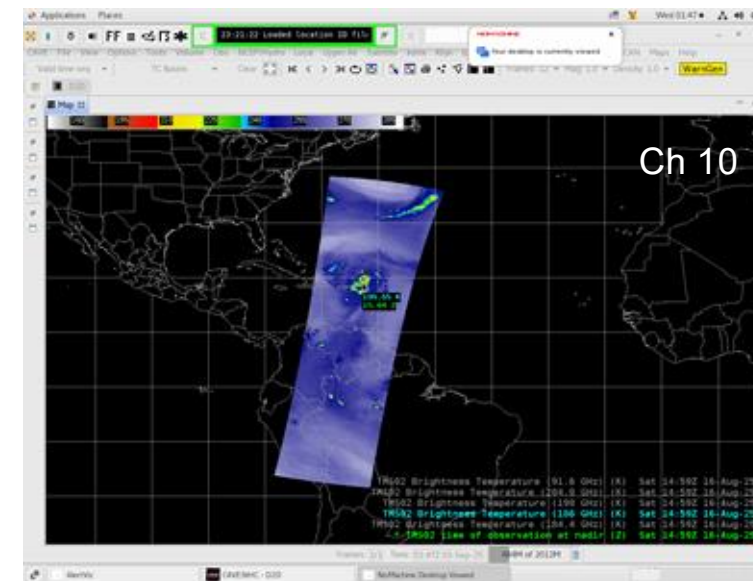
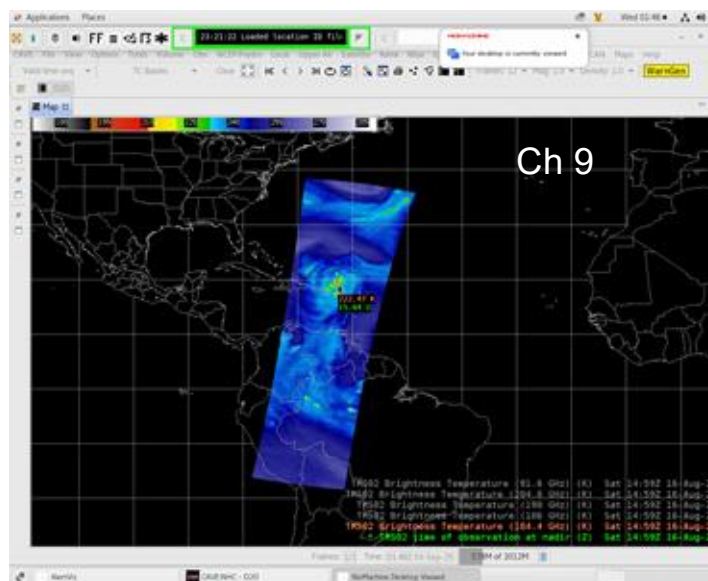
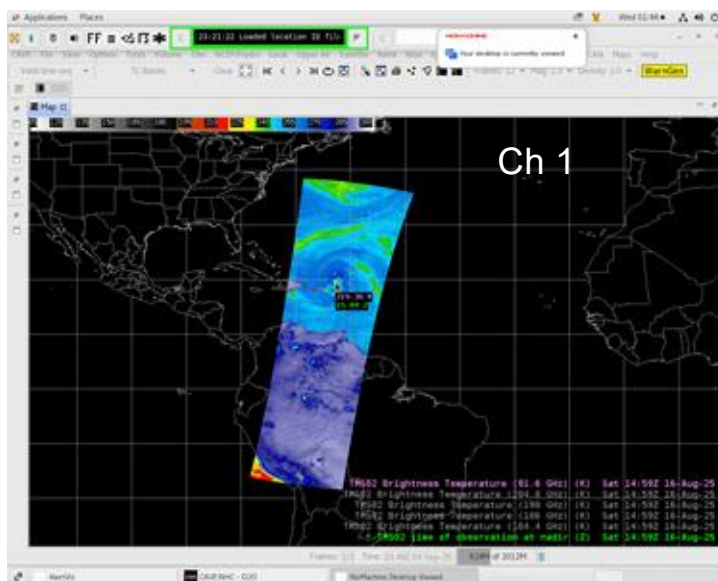
TPW



Tropical Cyclone Intensity Estimates



TC Imagery in *AWIPS – Operational Test



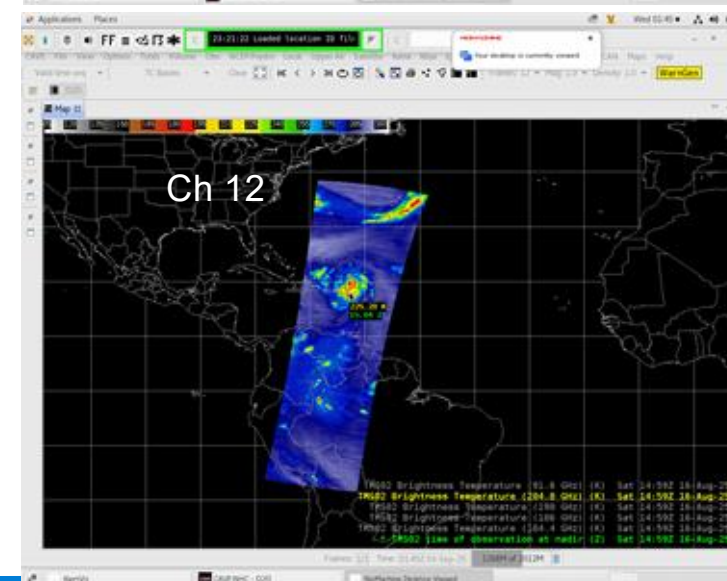
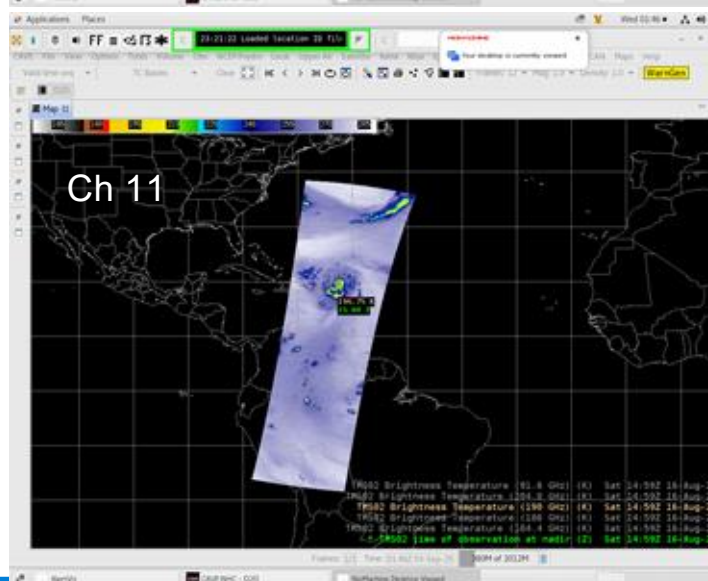
- ❑ NHC, *CPHC and *JTWC have interest in 91, 184, 186, 190, 205 GHz (channels 1, 9, 10, 11, 12)
- ❑ *TOWR-S is delivering the imagery to NHC in NRT.
- ❑ On going Coordination with JTWC to provide Tomorrow.IO AWIPS imagery

*AWIPS: Advanced Weather Interactive Processing System

*TOWR-S: Total Operational Weather Readiness

*CPHC: Central Pacific Hurricane Center

*JTWC: Joint Typhoon Warning Center



Lessons Learned

❑ Lessons Learned

- Commercial MWS data can complement NOAA systems for storm tracking, and moisture monitoring.
- Data reliability is critical – dropouts and latency affect operational usability.
- Short CubeSat lifespans highlight the importance of robust sensor design or accelerated replacement strategies.
- Strong vendor collaboration facilitates data quality and satellite performance improvements.
- AI/ML tools improve data processing efficiency and reduce human errors.
- Optimize and expedite Cal/Val and algorithms to deliver accurate, consistent, and operationally ready data aligned with ATMS.

❑ Areas for Improvement

- Data availability and stability improvement via ATMS
- Marginal data latency may impact operational performance

❑ Limitations

- CubeSat platforms have shorter lifespans compared to ATMS.
- 118 GHz offer less information content than 50 GHz; further analysis and user feedback are needed to understand the impact.
 - Trade-off is higher refresh for less precise Temp. information.



Interim Summary and Recommendations

☐ Data performance generally meets pilot requirements

- Level 1B/1C data are well-calibrated, comparable to ATMS, with only minor performance differences due to fewer channels.
- Higher temporal resolution and revisit rate offer significant value for tropical cyclone and precipitation tracking.
- Key Level 2 products, water vapor profile, rain rate, etc. meet JPSS requirements.
- Results demonstrate clear potential for NWS applications and alignment with pilot objectives.

☐ Next Steps

- Further analysis and user feedback are needed to understand the temperature channel impact.
 - Proceeding with GFS cycle experiments to evaluate impact on NWS forecasts.
- Refined algorithms prepare for the best operational practices.
- Improved AI data processing to expedite data processing to support operational delivery.

☐ Follow-on MWS pilot underway this year



Questions?



NESDIS Commercial Data Program Information:

<https://www.nesdis.noaa.gov/commercial-data-program>

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MWS Data Pilot Awards Summary



- **Award Date:** September 17, 2024
- **Total Award Value:** \$4,266,400
- **Recipients:**
 - Tomorrow.io (Boston, MA): \$2,266,400
 - Orbital Micro Systems – now Weather Stream (Boulder, CO): \$2,000,000

Purpose: To evaluate the quality, characteristics, and overall impact of commercial microwave sounder (MWS) data from low Earth orbit (LEO) satellites in support of NOAA's operational weather modeling and environmental monitoring missions.

Data Products Assessed:

- All-weather temperature and moisture profiles
- Derived products including Tropical Cyclone Imagery/data, precipitation and select land/hydrology parameters

Performance Period: 12 months, structured in three phases for data delivery, evaluation, and reporting

- Data delivery extended from 6 to 9 months to cover hurricane season

