Tropical Cyclone Intensity and Imagery Products from the TROPICS Smallsat Satellite Constellation

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CIMSS radiance-based TC Intensity Estimate (TCIE) algorithm update

- **Improved position location**. Updated center location code to address some missed centers.

- **Updated mixing corrections**. To remove lower channel mixing.   Pathfinder/T5 and T3/T6-dependent.

- **Updated intensity coefficients**. Based on new statistical analysis.

- **Added channel 9 contribution**. Convolve 183 GHz to thermal channel scans to determine % of TC eyewall in the scan.
     Values < 0 (in degrees C) indicate likely dominant attenuation.

- **Added quality flags**. Quality flags (0-2) based on TC eye size and convolved 183 GHz signal. 0 = best

- **Addressed unrepresentative cold environmental Tb values used in our TC temp anomaly calculation**.
     Now filters temperatures in the 5-7 degree annulus and removes cold Tb values due to convective attenuation.

- **TCIE now uses L1b ver. 04.01.01 for T6/T3 and 03.04.01 for Pathfinder/T5 for post analysis**
     NRT product still uses L1b version 03.04.01

- **Transition code out of Beta testing -> Provisional**

TCIE Performance (so far)

2021-2023 cases coincident with recon data (some WPac cases using best track)

Highest TCIE errors at larger scan angles. This appears to be regardless of eye diameter (eyewall convection attenuation)

Larger errors for TCs with small eyes. Despite eye size corrections, often the eyewall attenuation effects can dominate the eye warming.

Some too-weak errors are due to erroneous eye size inputs (either from automated sat estimates like ARCHER or from agency ATCF values). ARCHER using TROPICS can help.

Some examples and mitigation efforts follow
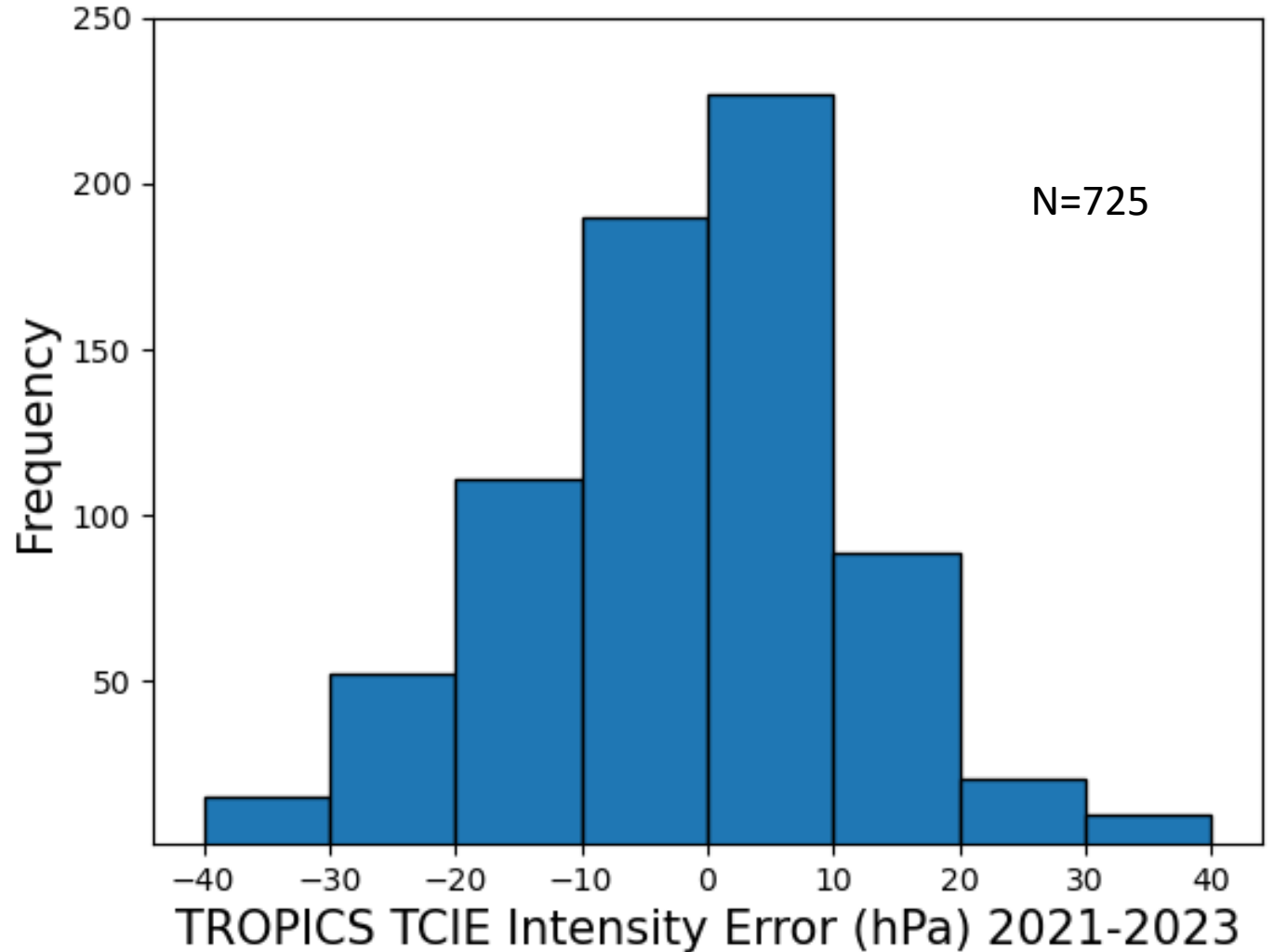
Environmental Tb can be impacted by outer band convective attenuation

This requires filtering to remove spurious values from the env temperature annulus used in computing the TC temp anomaly that TCIE relies on to produce an intensity estimate.

In the example to the right Koinu is in the genesis stage but the temperature anomaly would be artificially inflated by the attenuated Tb values in the environmental Tb annulus leading to a much too strong Tb anomaly
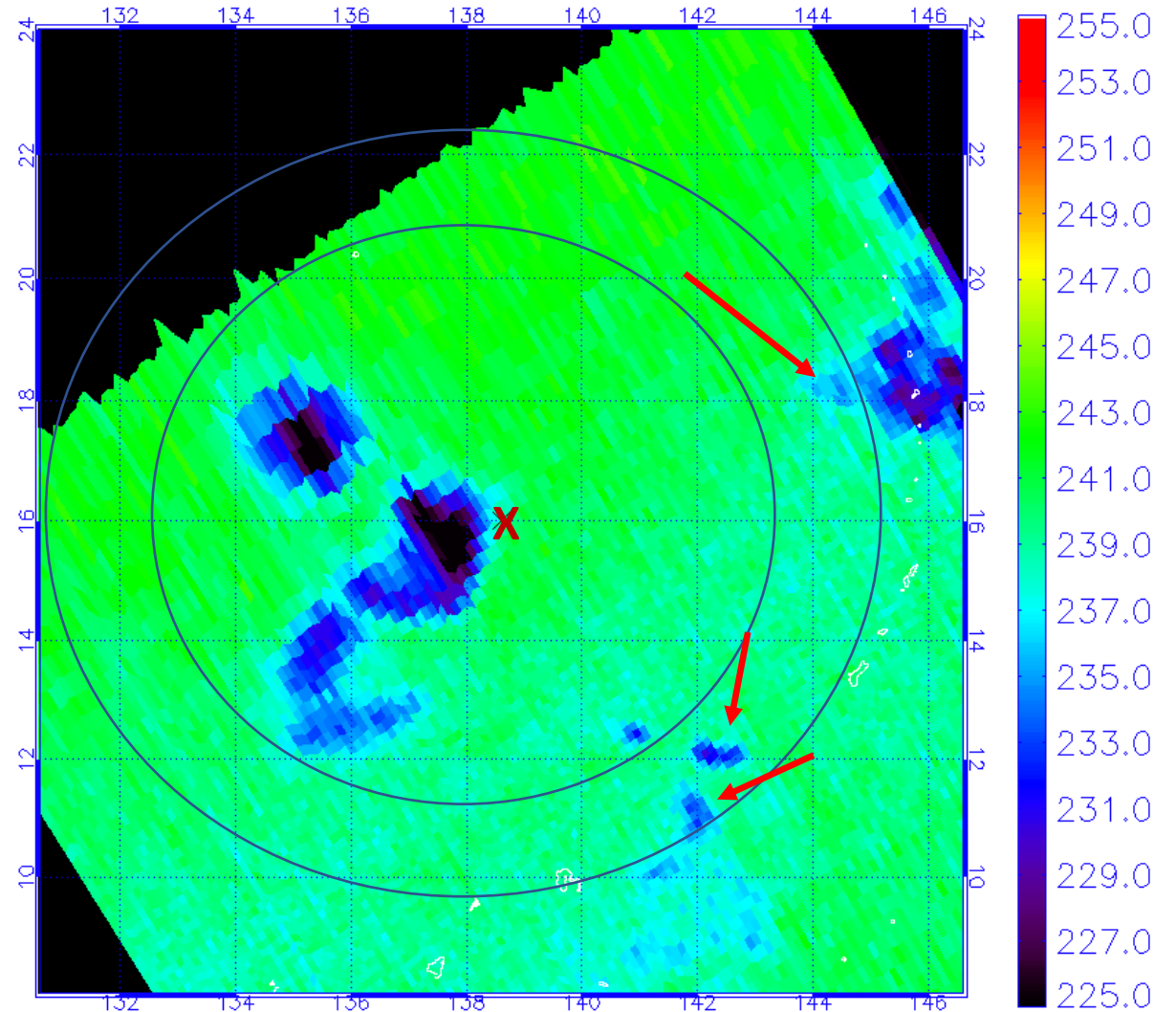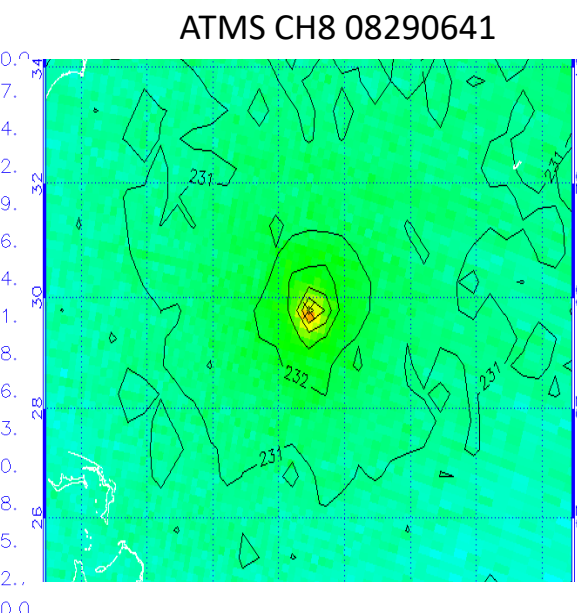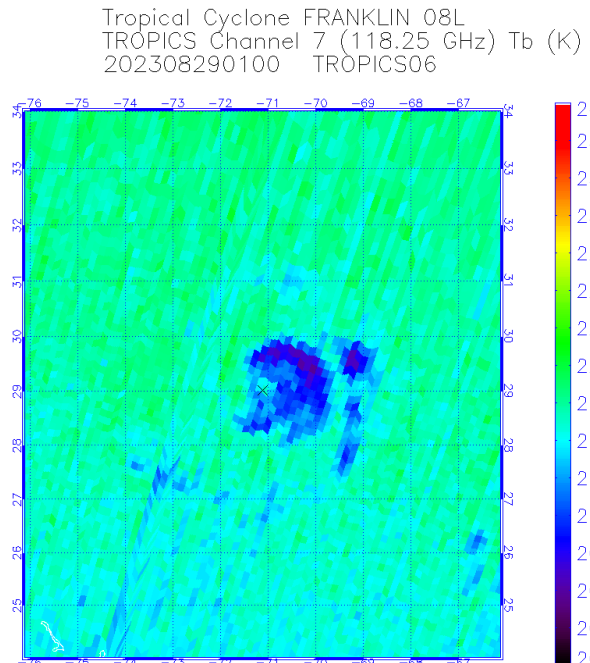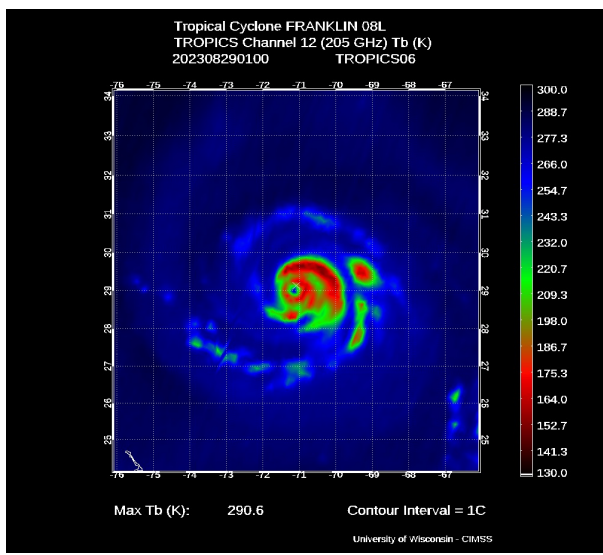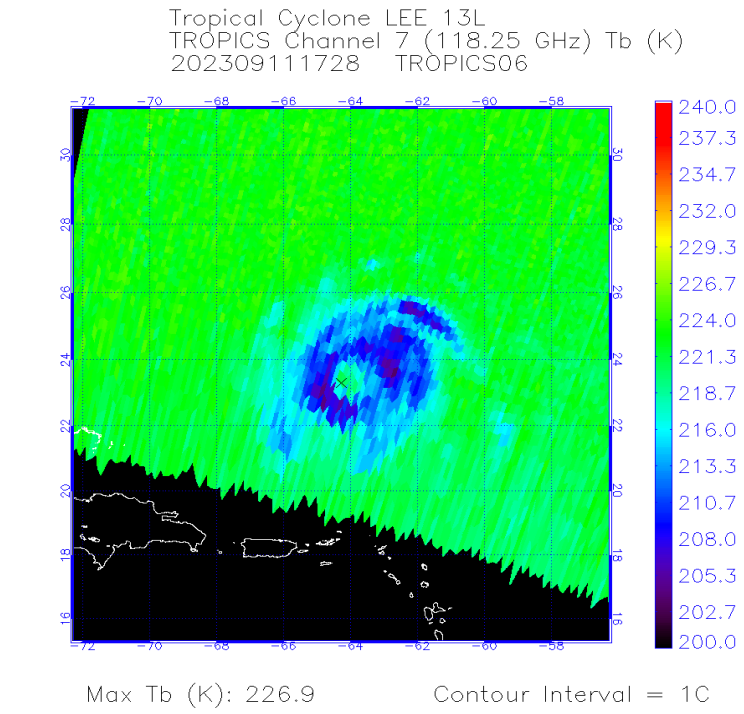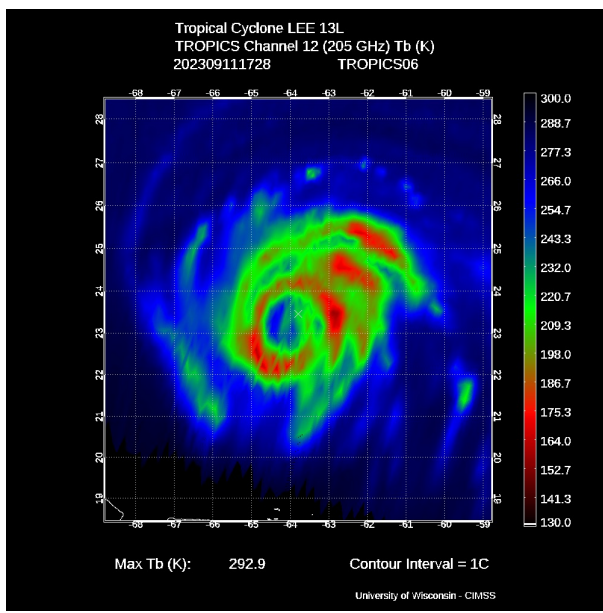
Examples of largest TCIE errors

TC Franklin (2023)
Pinhole eye, no warm core detected
Best Track: 925 mb
TCIE ~60 mb weak
qflag = 2 (poor confidence)
    - small eye and lots of attenuation

TC Lee (2023)
Edge of swath, Relict Eyewall
Best Track: 949 mb
TCIE ~60 mb weak
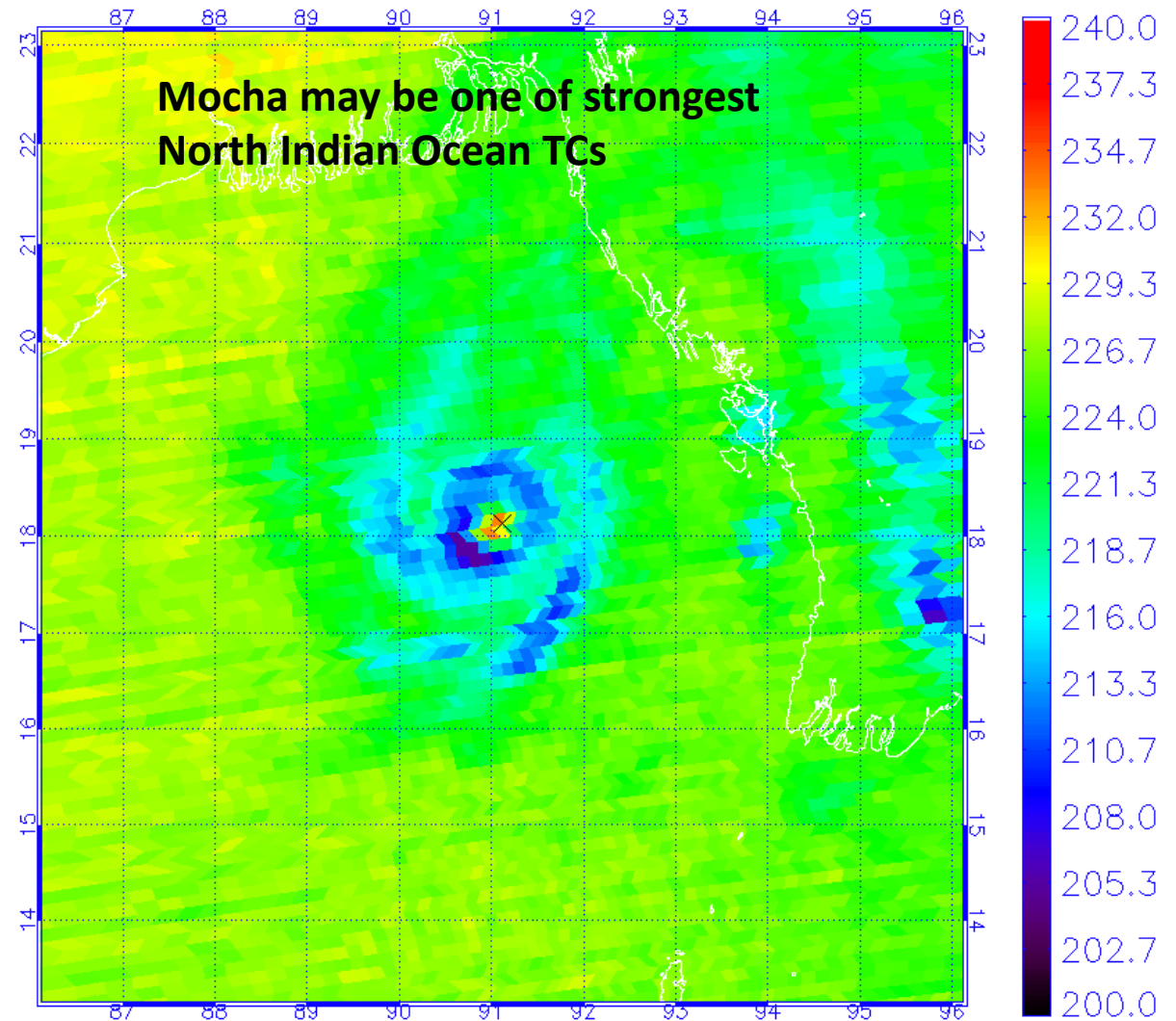**qflag= 1 (fair confidence)**
    - large eye but near edge of swath

**Note associated quality flags attempt
to provide estimate confidence**

Tropical Cyclone FRANKLIN 08L
TROPICS Channel 7 (118.25 GHz) Tb (K)
202308290100   TROPICS06

ATMS CH8 08290641

Tropical Cyclone FRANKLIN 08L
TROPICS Channel 12 (205 GHz) Tb (K)
202308290100   TROPICS06
Max Tb (K):   290.6   Contour Interval = 1C
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Tropical Cyclone LEE 13L
TROPICS Channel 7 (118.25 GHz) Tb (K)
202309111728   TROPICS06

Tropical Cyclone LEE 13L
TROPICS Channel 12 (205 GHz) Tb (K)
202309111728   TROPICS06
Max Tb (K):   292.9   Contour Interval = 1C
University of Wisconsin - CIMSS

Max Tb (K): 226.9   Contour Interval = 1C
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Best cases result for near-nadir passes over well-centered strong TCs with larger eyes such as Cyclone Mocha (01B) 2023

TCIE: 908 hPa

Best Track: 915 hPA

qlfag =1 (Fair confidence)
 - Eye ~ 40 km but convolved 183 GHz suggests caution

Tropical Cyclone   MOCHA 01B
TROPICS Channel 7 (118.25 GHz) Tb (K)
202305132012   TROPICS01

Mocha may be one of strongest North Indian Ocean TCs

Max Tb (K): 233.2   Contour Interval = 1C

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Another good example:
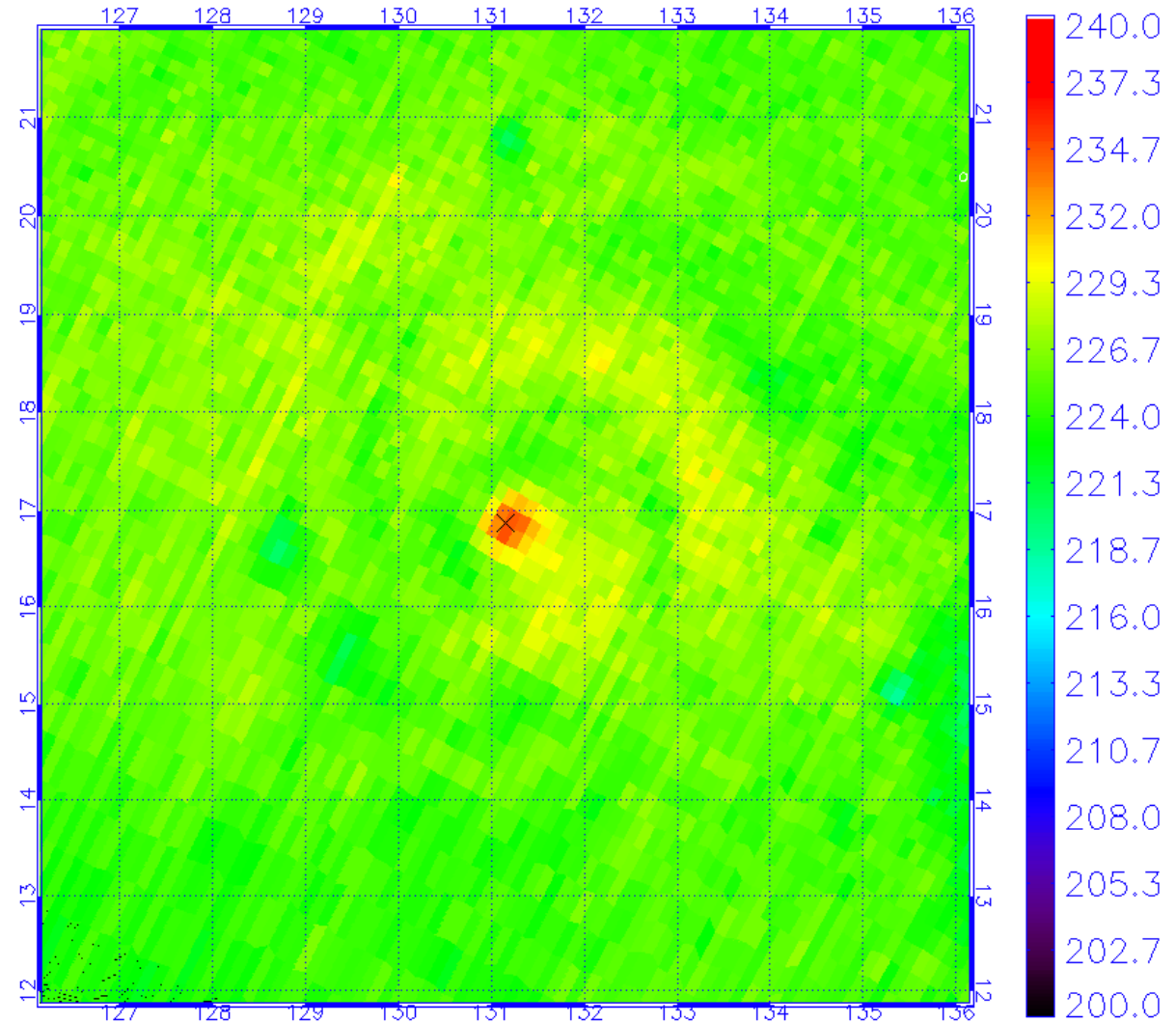**WestPac Typhoon Mawar (02W) 2023**

TCIE: 927 hPa and 125 knots

Best Track: 925 hPA and 130 knots

qflag = 0 (higher confidence)
- larger eye and no attenuation

Note: This TC had the strongest warm core observed by ATMS a day earlier on 26th of May

Tropical Cyclone   MAWAR 02W
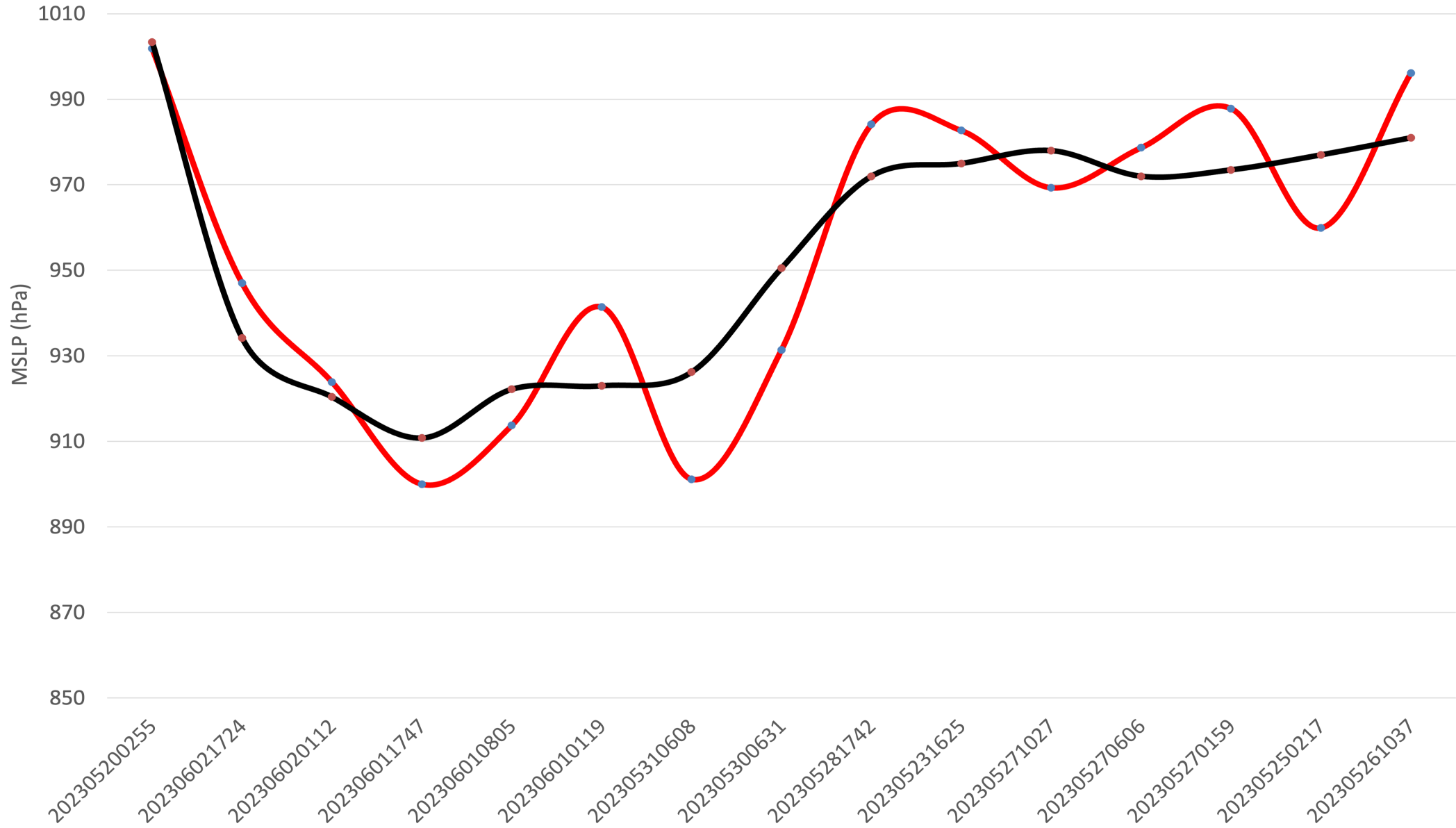TROPICS Channel 7 (118.25 GHz) Tb (K)
202305271028   TROPICS05

Max Tb (K): 234.7   Contour Interval = 1C

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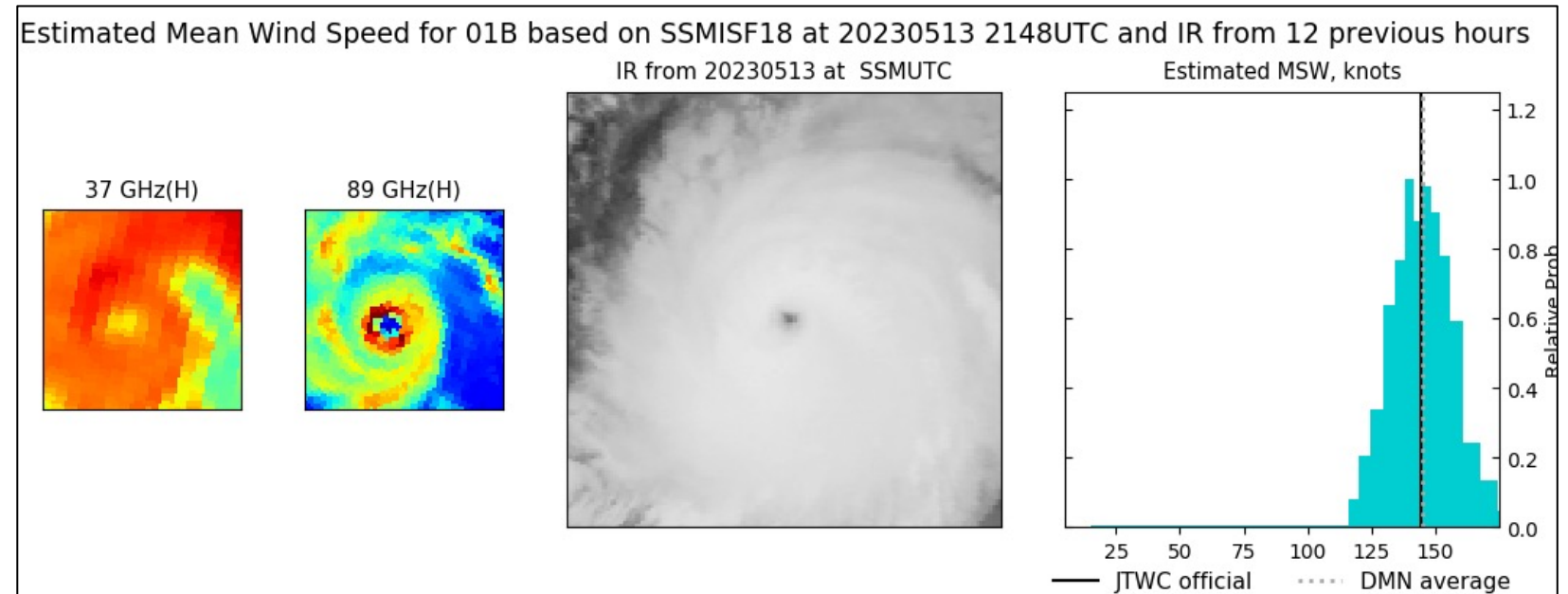
Typhoon Mawar (02W 2023)

A Different Approach to Estimate TC Intensity from TROPICS: D-MINT183

- Rather than estimate intensity by warm core strength, employ the CIMSS D-MINT CNN model to analyze the TC convective structure/organization as viewed from the TROPICS moisture channels and find relationship to intensity

D-MINT operates on microwave imagery

Example at right: D-MINT for Cyclone Mocha (2023) using SSMIS F-18 data

Estimated Mean Wind Speed for 01B based on SSMISF18 at 20230513 2148UTC and IR from 12 previous hours

- Because 183 GHz is unaffected by lower channel mixing and has good analogs in AMSU/ATMS/SSMIS, we apply the CIMSS D-MINT CNN model to TROPICS 183 GHz channels 9 and 10 (no analog for 205 GHz presently)

- D-MINT183 uses 183 GHz, geostatic IR and environmental inputs from SHIPS (Shear, sst, etc), and for now, requires 75% of TC covered in inner 50% of overpass swath

Different approach, can compliment temperature channel-based TCIE

TC Intensity Estimates (Vmax) for Occurrences of TROPICS Overpasses during 2021-2024 (All Basins)
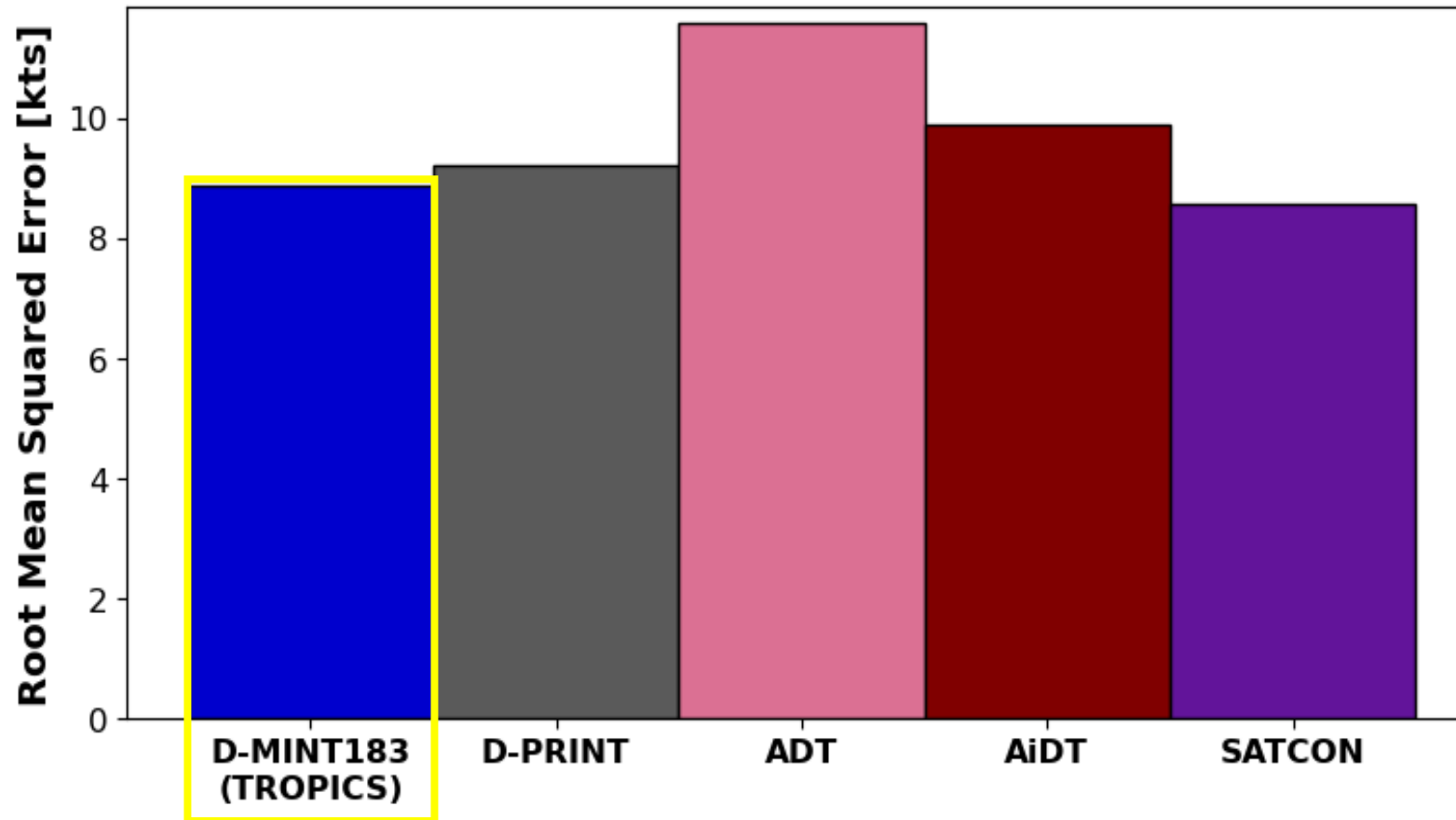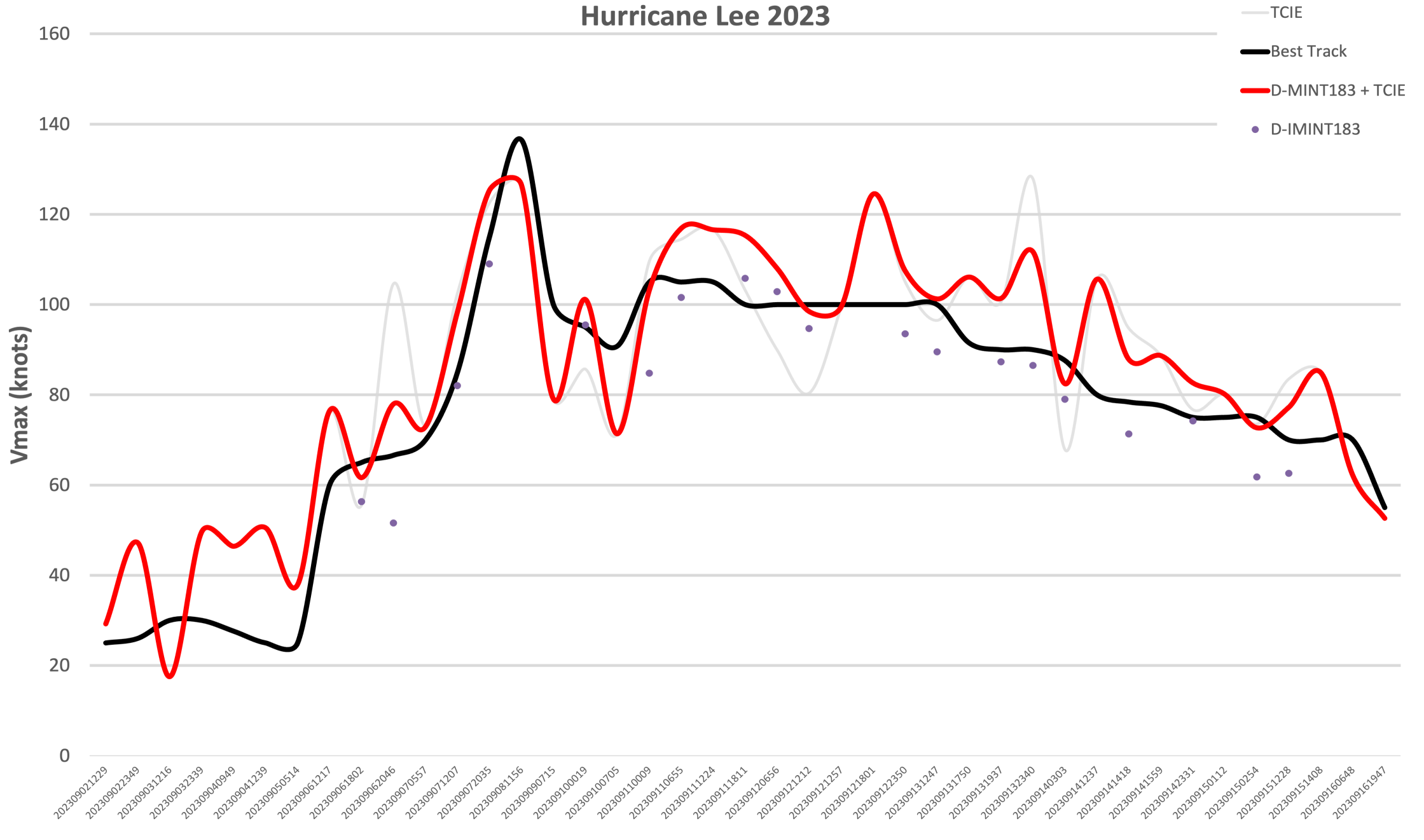
# of homogeneous estimates: 863

- for D-MINT183, overpass must cover at least 65% of the TC within the inner 50% of the scan swath
  - nearest D-PRINT/ADT/AiDT/SATCON within 30mins of TROPICS overpass

*See Sarah Griffin's talk Thursday 2:45 pm 15D.4 - Predicting Current and Short-Term Intensity Change in Tropical Cyclones Using a CNN

Hurricane Lee 2023

CIMSS TROPICS Products Near Real-Time Display

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CURRENT TROPICS ESTIMATE
  CIMSS TROPICS TC Intensity Estimation:
  2023 0528 1742 02W
  Latitude: 18.153 Longitude: 126.869
  Storm position corresponds to TROPICS CH7 FOV 58 [1<--->96]
  --------------- SAT is TROPICS01 ------------------------------------
  | Estimated MSLP:                    944.6 hPa
  | Estimated Maximum Sustained Wind:   80.6 kts
  Channel 7 Tb Anomaly: 8.0
  Channel 6 Tb Anomaly: 6.5
  EYE: 64.4561 km
  Environmental Pressure: 1005
  ARCHER score used is: 70.1

History for 202302W
Year    Date      Time  Lat     Lon     Satellite    FOV    Resdif   Tb6a   Tb7a   Tb9    Penv   Eye_sz  ARCHER_score   TMSLP    TVmax
2023    20230528  1742  18.15   126.90  TROPICS01    58     125.51   6.5    8.0    243.0  1005   64.5    70.1           944.6    80.6
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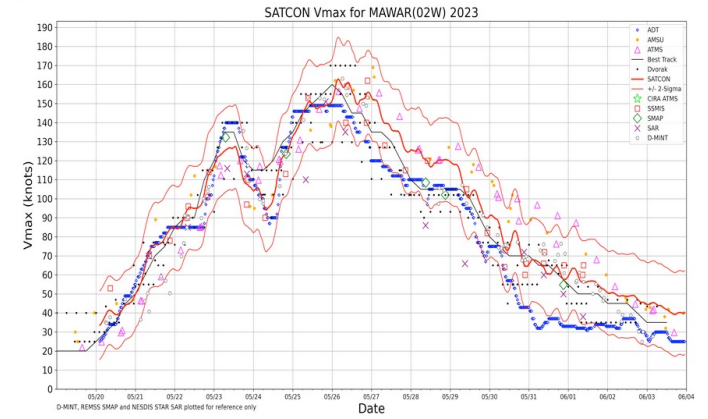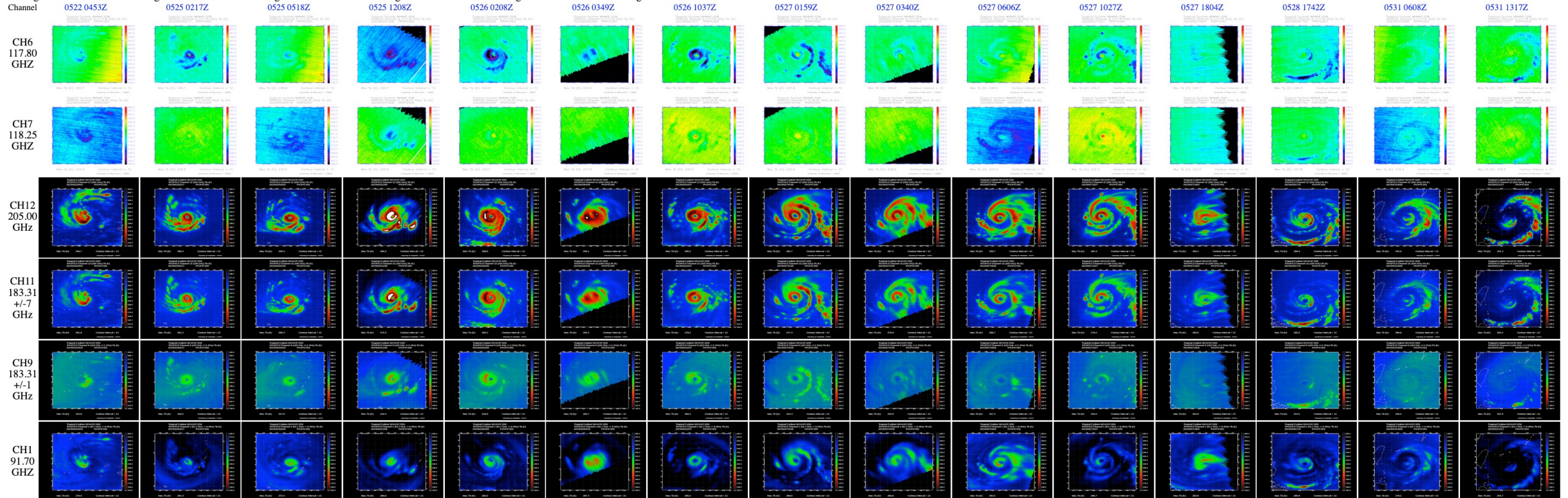

SATCON Vmax for MAWAR(02W) 2023

Future Work to Improve TCIE Estimates

- **Address outliers.** Improved mixing corrections or other mitigation to de-convolve the channels and maximize signal

- **Attenuation effects**. Ice water path or other derived values to deal with the impact of hydrometeors on Tb. NN retrievals.

- **ARCHER implementation**. ARCHER provides eye size inputs using PMW sensors. Apply to TROPICS data when eye is clear.

- **Continue development of D-MINT183 for TROPICS**

- **Quantify TCIE and or D-MINT183 TROPICS suitability for input to SATCON**

- **TROPICS ERC prediction tools such as M-PERC183**

TROPICS Channel 12
205 GHz for Jasper 2023

Tropical Cyclone   JASPER 03P
TROPICS Channel 11 (183 GHz) Tb (K)
202312050027   TROPICS05

Max Tb (K):   276.8   Contour Interval = 1C

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