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The role of convective cycles in modulating tropical cyclone intensity: A comparative analysis of rapid vs non-rapid intensification cases using high-resolution satellite imagery.

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MOTIVATION AND RESEARCH QUESTION

- ➔ Despite favorable environmental conditions (SST > 28.5°C, low shear, high VMPI), the prediction of RI in TCs exhibits high false alarm rates.
- ➔ The relationship between Convection organization patterns and TC intensification remains not well understood.

What distinctive convective features differentiate Rapidly Intensifying (RI) cases from Non-rapidly Intensifying (NI) ones in TCs, regardless of environmental conditions?

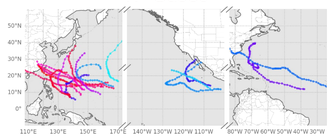
DATA & METHODOLOGY

- ➔ SHIPS and IBTrACS database for environmental conditions.
- ➔ GOES-16/17 & Himawari-8 IR imagery (BT-CH13)

Case selection: 35 TCs

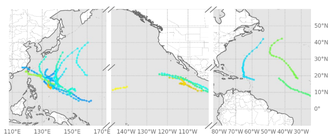
With Favorable Conditions
Across 3 Basins (AL,EP,WP)

Rapid Intensification (RI)
17 Cases



Typhoon SURIGAE	2021	Typhoon JELAWAT	2018
Typhoon MERANTI	2016	Hurricane ROSA	2018
Typhoon HAGIBIS	2019	Hurricane SERGIO	2018
Typhoon NEPARTAK	2016	Typhoon FENGSHEN	2019
Typhoon SOUDELOR	2015	Hurricane JULIETTE	2019
Typhoon MANGKHUT	2018	Typhoon BANYAN	2017
Typhoon MARIA	2018	Hurricane FLORENCE	2018
Typhoon BUALOI	2019	Hurricane JOSE	2017
Typhoon LAN	2017		

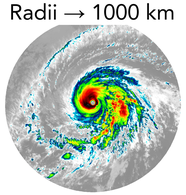
Non-rapid Intensification (NI)
18 Cases



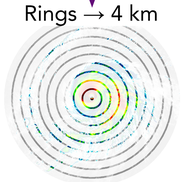
Typhoon MAN-YI	2018	Tropical Storm ATSANI	2020
Typhoon MEARI	2016	Tropical Storm BLANCA	2021
Typhoon MALOU	2021	Tropical Storm GUILLERMO	2021
Hurricane ESTELLE	2022	Tropical Storm PAINE	2022
Typhoon CHAMPI	2021	Tropical Storm MUIFA	2017
Typhoon SAOLA	2017	Typhoon IN-FA	2015
Typhoon KUJIRA	2020	Typhoon MEGI	2016
Tropical Storm CRISTINA	2020	Tropical Storm AKONI	2019
Tropical Storm VICTOR	2021	Hurricane EARL	2022

FEATURE DETECTION

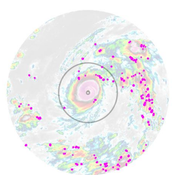
Radii → 1000 km



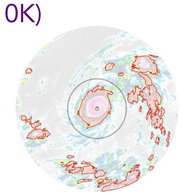
Rings → 4 km



Hot Towers (204K/211K)
Size : 4-300 km²
Max Eccentricity: 0.85
Min 2K/4K colder than anvil



Convective Clusters (180-210K)
Rain bands (210-220K)
CC Min size 1000 km²
RB Min Eccentricity: 0.95
RB Min len-wid: 30-50 km



Acknowledgments: This work was presented with travel support from the AMS Student Travel Allowance for the 7th Special Symposium on Tropical Meteorology and Tropical Cyclones.

RADIAL DISTRIBUTION OF CONVECTION

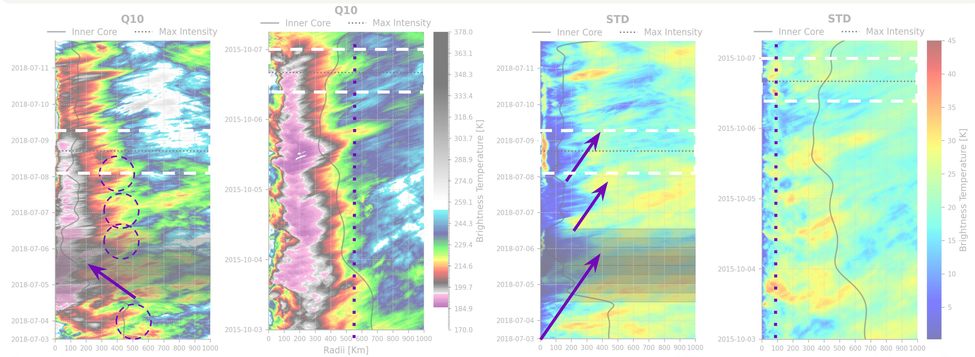


Figure 1. Characterization of deep convection (Q10) and degree of organization of convection (STD) for typical RI cases and NI cases. The periods of rapid intensification are indicated with a slight faint shadow, with white lines the time when the maximum intensity was reached is indicated. Important behaviors of convection for typical cases are indicated with purple color. Note the distinctive 24-hour convective cycles in RI cases showing expansion-contraction patterns and alternating organization states, absent in NI scenarios.

ANALYSIS OF CONVECTIVE INDIVIDUALS DURING STORM DEVELOPMENT

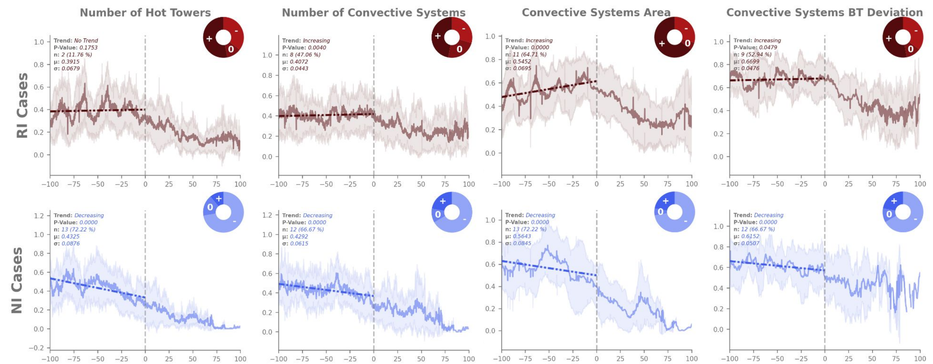


Figure 2. Standardized convective characteristics comparing RI (red) and NI (blue) cases. Variables are centered at the point of maximum intensity (t=0, vertical dashed line).Pie charts indicate the distribution of trends before maximum intensity (+ increasing, 0 no trend, - decreasing). RI cases exhibit expanding convective areas (64.71%) and increased BT variability (52.94%), while NI cases show systematic decreases in both convective area (72.22%) and BT variation (66.67%), suggesting distinct organizational processes between intensification regimes.

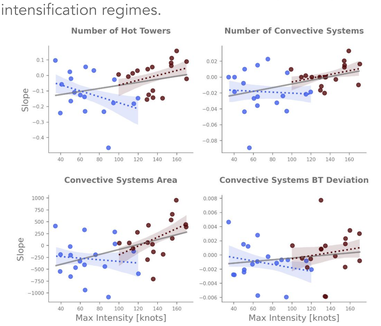


Figure 3. Analysis of convective characteristics in TCs showing the relationship with maximum intensity. Shaded areas represent the 95% confidence intervals. RI cases exhibit positive correlations between maximum intensity and all convective metrics, while NI cases show negative slopes, highlighting how organized convection patterns influence ultimate TC strength.

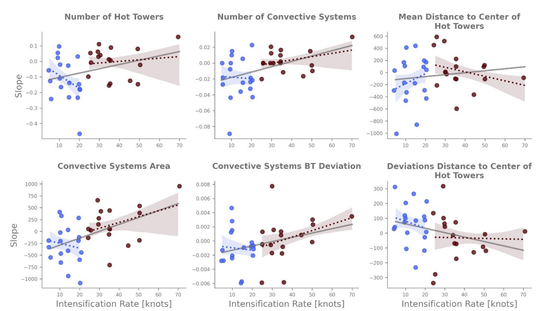


Figure 4. Analysis of convective characteristics in TCs showing the relationship with maximum intensification rate. Shaded areas represent the 95% confidence intervals. Higher intensification rates correlate strongly with increased convective organization, area expansion, and clustering of HTs closer to the center, demonstrating how rapid development depends on efficient convective structuring.

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LinkedIn (https://www.linkedin.com/in/duvannieves/)

CONVECTION CYCLES DURING STORM

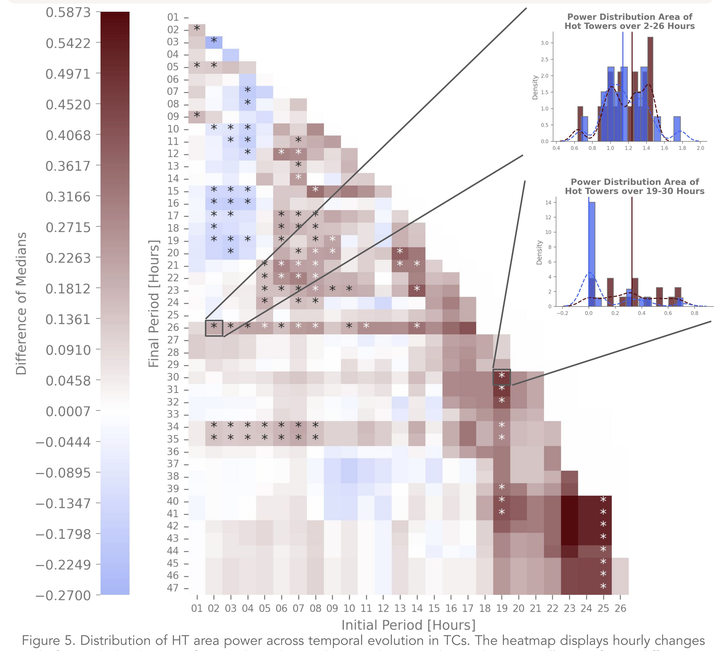


Figure 5. Distribution of HT area power across temporal evolution in TCs. The heatmap displays hourly changes with focused distributions for 2-26h and 19-30h periods. Asterisks mark statistically significant differences (p<0.05) between RI and NI cases. The distinct bands of higher power during 6-12h and 21-26h periods demonstrate organized cyclic convection in RI cases, contrasting with NI cases' weaker temporal coherence, highlighting the importance of structured convective cycles for sustained intensification.

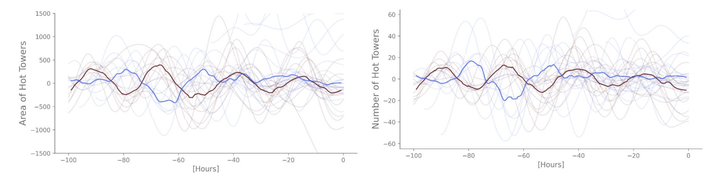


Figure 6. Filtered temporal patterns of HT counts and areas before maximum intensity (t=0), focusing on cycles >16 hours. RI cases (red) display consistent 4-5 oscillation before maximum intensity cycles with clear periodicity, while NI cases (blue) exhibit at most 2 irregular cycles, demonstrating how sustained convective pulsation characterizes rapid intensification.

SUMMARY AND FUTURE WORK

- ➔ Cyclical HT patterns and inner-core contraction distinguish RI from NI cases, with systematic differences in convective organization revealed through BT analysis.
- ➔ The trend in convective systems and HT cycles during RI provide potential new pathways for improved TC rapid intensification prediction.
- ➔ Temporal analysis reveals systematic ~24hr convective cycles in RI cases with 4-5 oscillations before maximum intensity, while NI cases show only 1-2 irregular pulses, indicating cycle persistence as a key RI predictor.
- ➔ Future work will focus on developing objective metrics for real-time RI detection through high-resolution modeling and expanded multi-basin analysis.

References