Diurnal Variation of Clouds Overshooting Tops Detected by Himawari-8 Satellite and Typhoon Intensity

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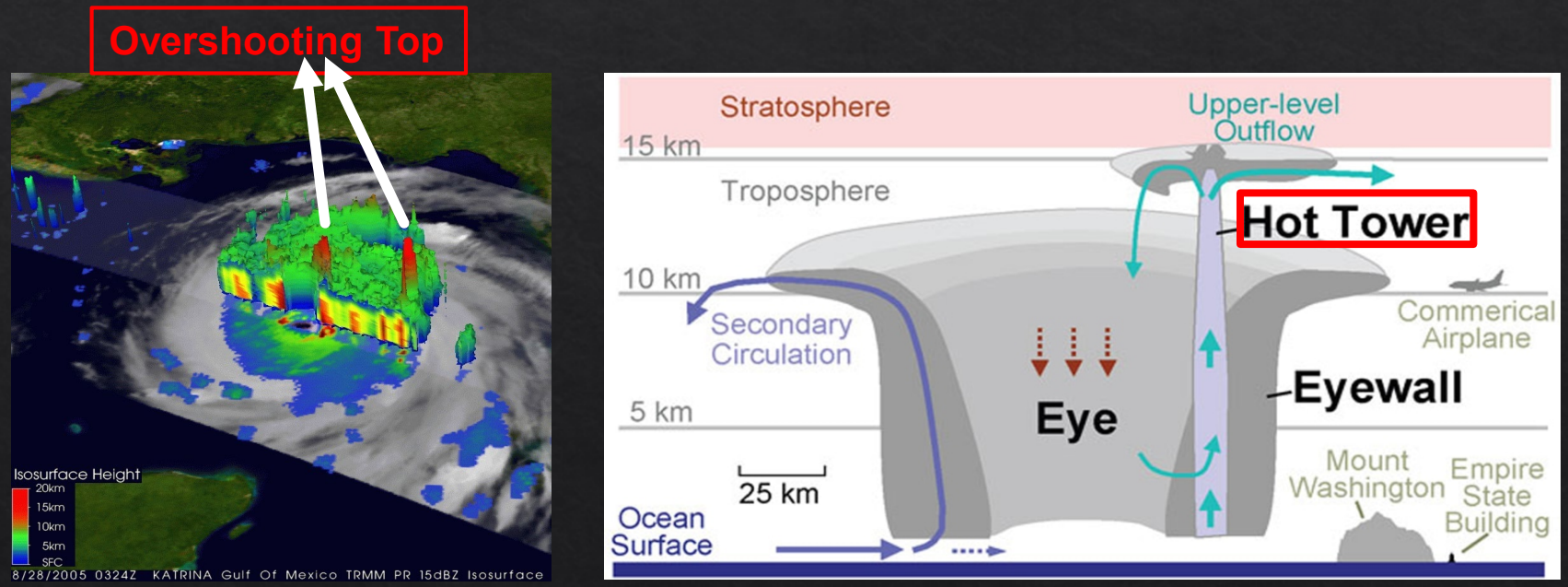
- Sun, Tang, et al., 2021: Diurnal Variation of Overshooting Tops in Typhoons Detected by Himawari-8 Satellite. *Geophysical Research Letters.*

Background

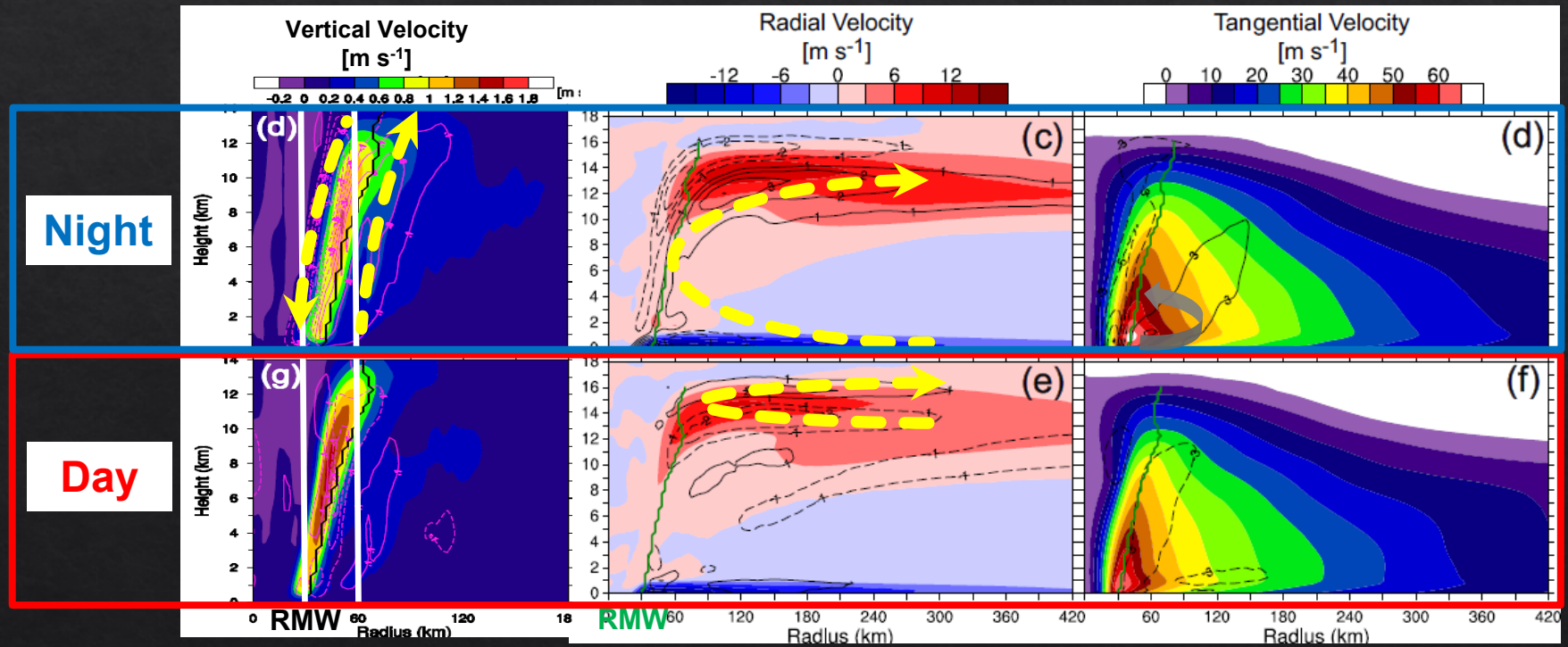
- **Overshooting Top (OT):**
  - a proxy for deep convection with an intense updraft that can penetrate the tropopause;
  - has an important influence on typhoon intensification;
  - also referred to as the hot tower or convective burst (Monette et al., 2012; Tang et al., 2019)



Credit: NASA

Background

- **Typhoon diurnal cycle:**
  - **Night**: Stronger updraft outside of RMW; Stronger low to middle level transverse circulation; Stronger tangential wind
  - **Day**: Smaller radius of maximum wind (RMW); Stronger upper-level transverse circulation



(Tang and Zhang 2016, JAS)

Scientific Questions

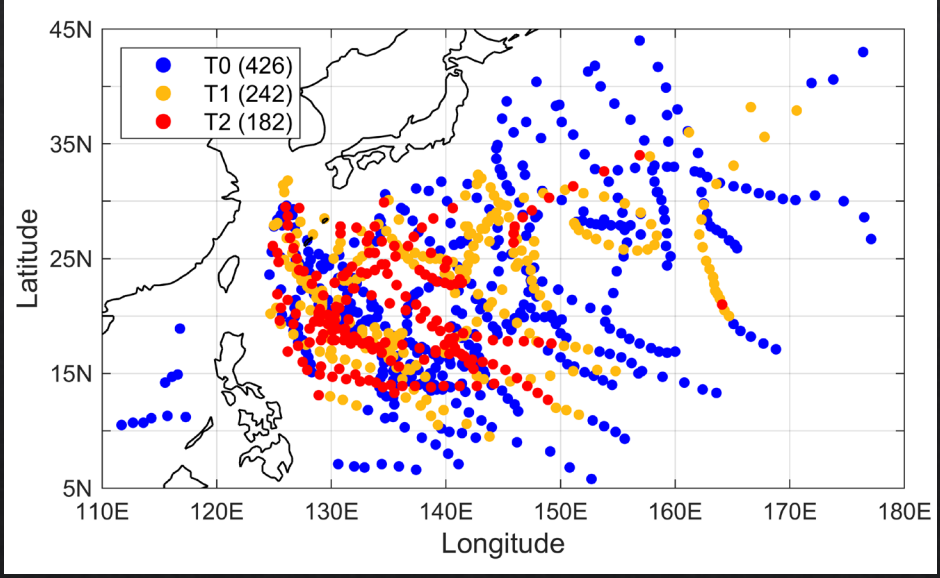
- What's the spatiotemporal distribution of OTs for different categories of intensity and intensity change of the western North Pacific (WNP) typhoons?
- What's the diurnal-scale relationship between OT occurrences and typhoon intensity changes?

Data Selection and Classification

- AHI/Himawari-8 images and best-track data (2016—2018)

◈ Criteria for selected typhoons and records:

- ✓ $V > 33$ kt
- ✓ Typhoon center 300 km away from landmasses
- ✓ Typhoon lifetime more than 24 hours



- 850 best-track records from 45 WNP typhoons are selected.

Groups of typhoon intensity (V):

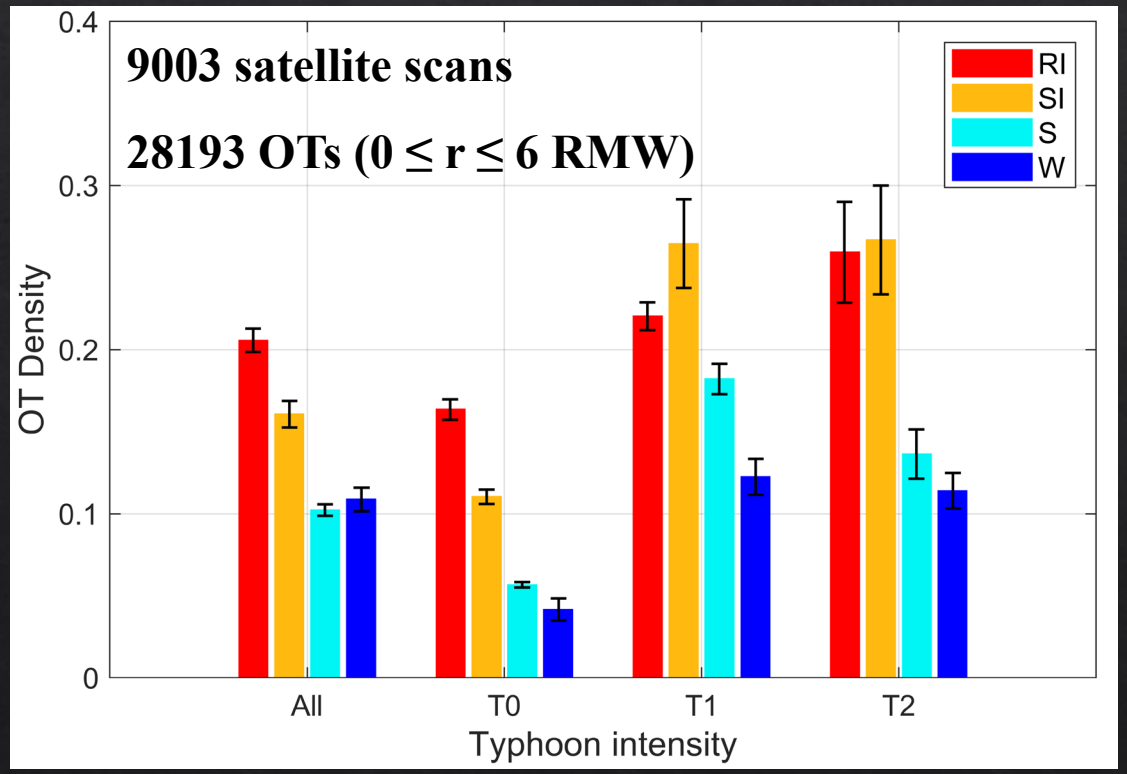
- T0: 33 kt < V ≤ 63 kt
- T1: 63 kt < V < 96 kt
- T2: V ≥ 96 kt

Types of 12-h intensity change:

$(\triangle V = V_{t12} - V_{t0})$

- RI: $\triangle V \geq 15$ kt
- SI: 5 kt $<\triangle V<$ 15 kt
- S: -5 kt $\leq \triangle V \leq$ 5 kt
- W: $\triangle V <$ 5 kt

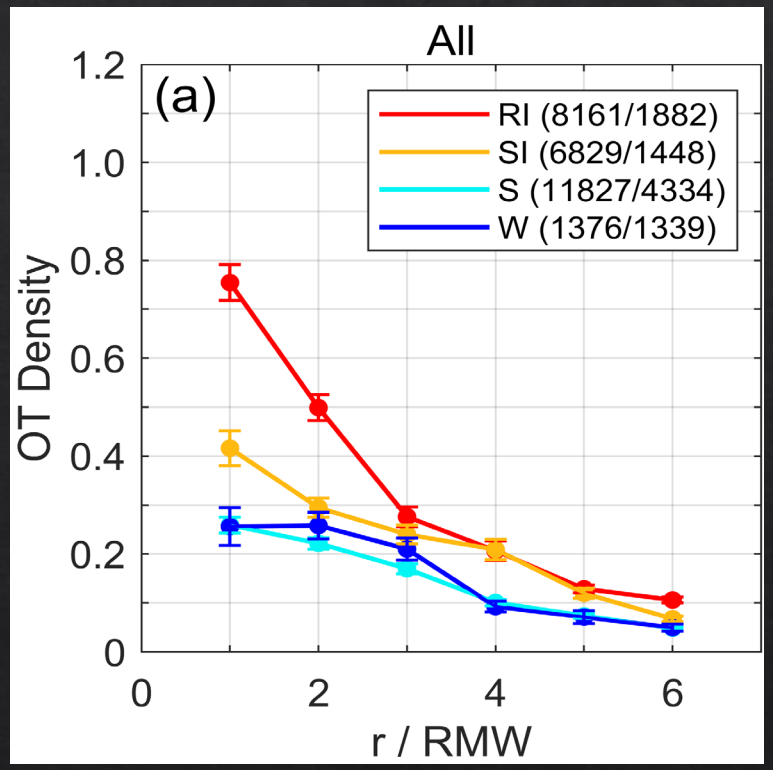
Distribution of OTs



OT density (OTD): the OT numbers per scan normalized by the unit area (100 km×100 km)

- OTD in strong (T1 and T2) typhoons is greater than in weak typhoons (T0), because of smaller RMW
- RI and SI typhoons have a much greater OTD than S and W typhoons, because of more OTs

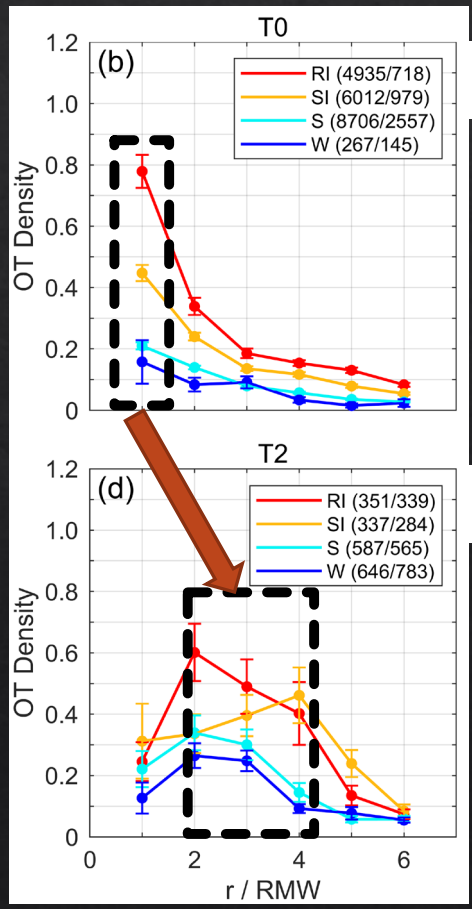
Distribution of OTs



- OTD in intensifying typhoons increased rapidly as the radius decreased, especially for the RI typhoons

Distribution of OTs

- OTD maximum gradually shifted from 1 to 2–4 RMW when the typhoon intensity increased from *T*0 to *T*2.
- Stronger warm-core effect in the central area of stronger typhoons suppressed the development of convection.

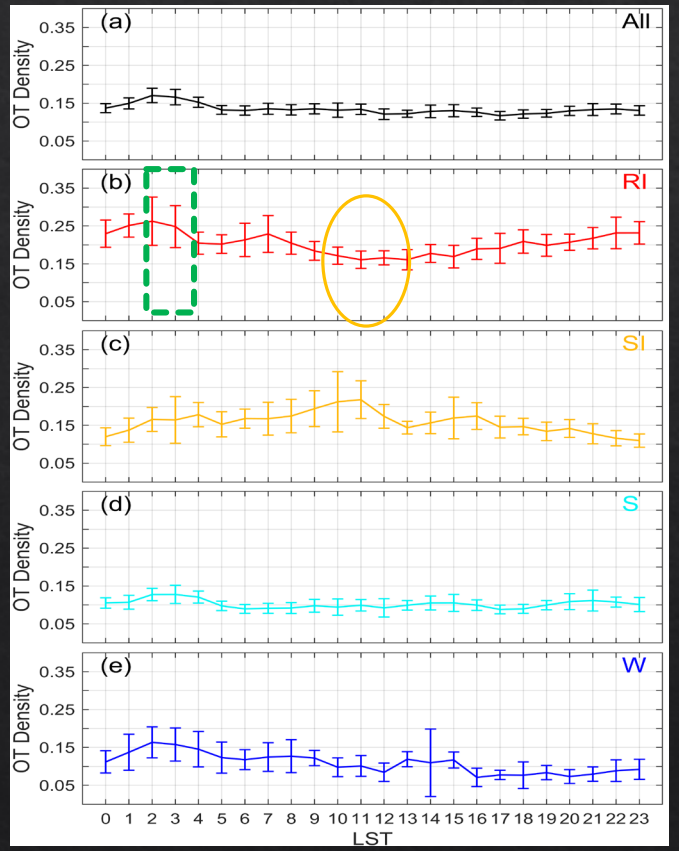


T0: Weak

T2: Stong

Diurnal Variations of OT and Intensification Rate

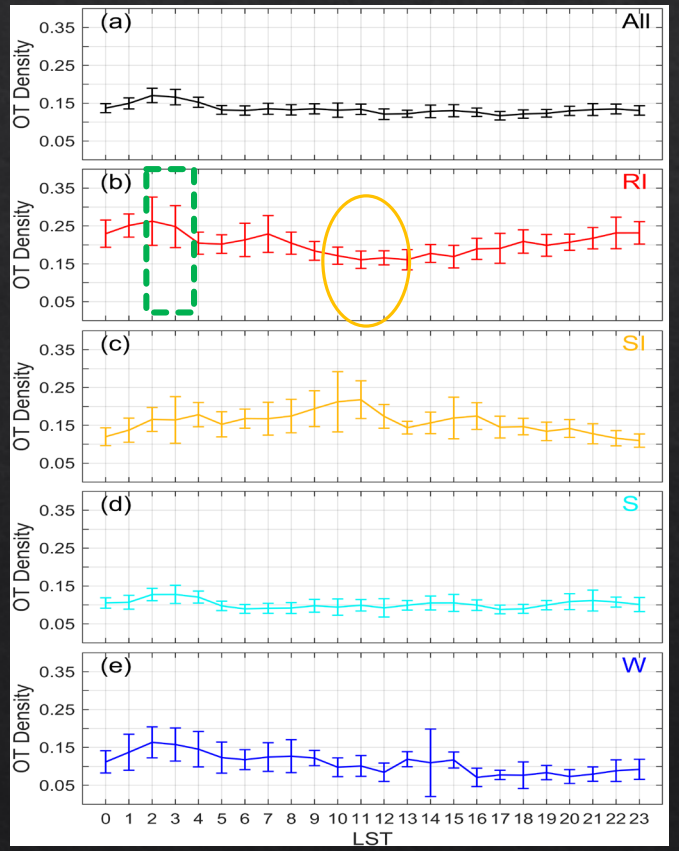
OT density (r ≤ 6 RMW)



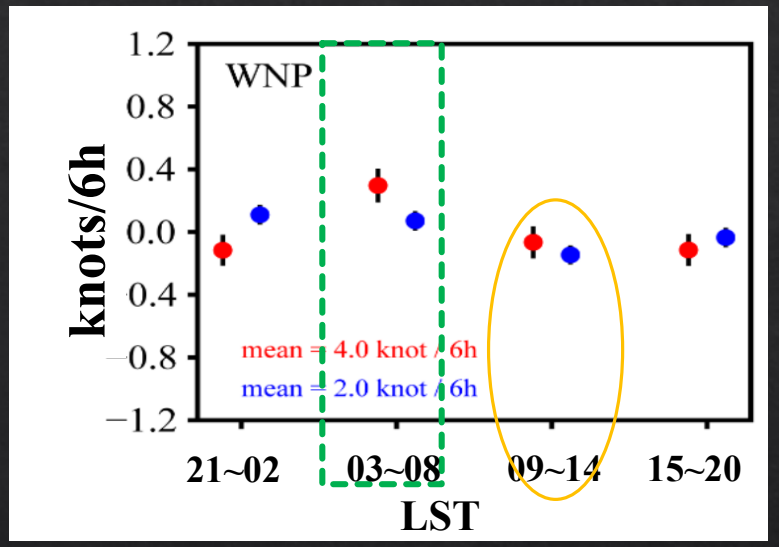
- **RI** typhoons showed the most prominent diurnal variation, with a **maximum** OTD at about **0200** LST and a **minimum** at **1100–1300** LST

Diurnal Variations of OT and Intensification Rate

OT density (r ≤ 6 RMW)



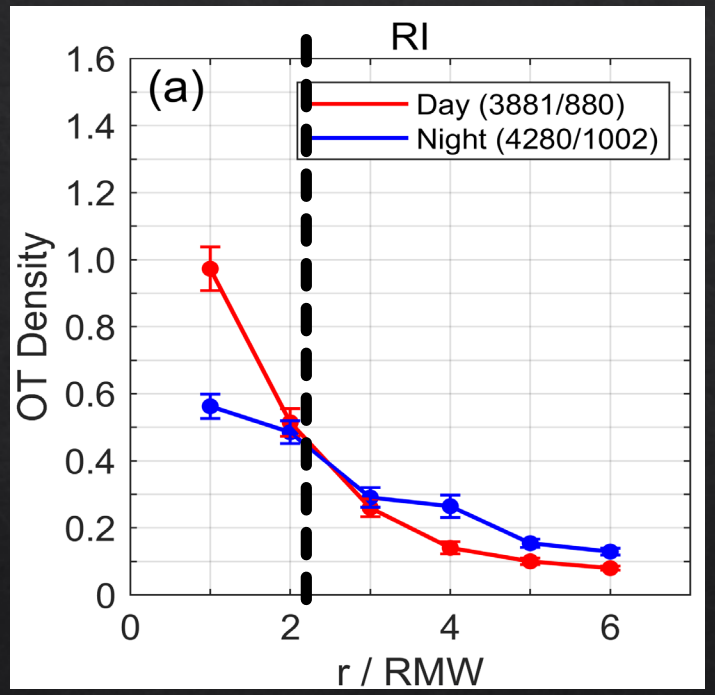
Intensification Rate



Wu et al. (2020)

- WNP typhoons often had a **maximum** intensification in the **nighttime (0300–0800 LST)** and a **minimum** during the **day (0900–1400 LST).**

Diurnal Variations of OT and Intensification Rate



- The diurnal phases of OTD are different outside and inside 2 RMW

Mechanism

net radiative cooling and radial differential radiation at night

↓

increased instability and stronger transverse circulation

↓

more OTs in the eyewall

→ strengthened compensatory downdraft and warm core in the typhoon eye

↓

the typhoon intensifies more rapidly through hydrostatic adjustment and gradient wind balance

(Tang & Zhang, 2016; Tang et al., 2019)