ESCAP/WMO Typhoon Committee
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JMA/MRI's 2025 Aircraft Observation: From High-Altitude Environment to Typhoon Inner Core

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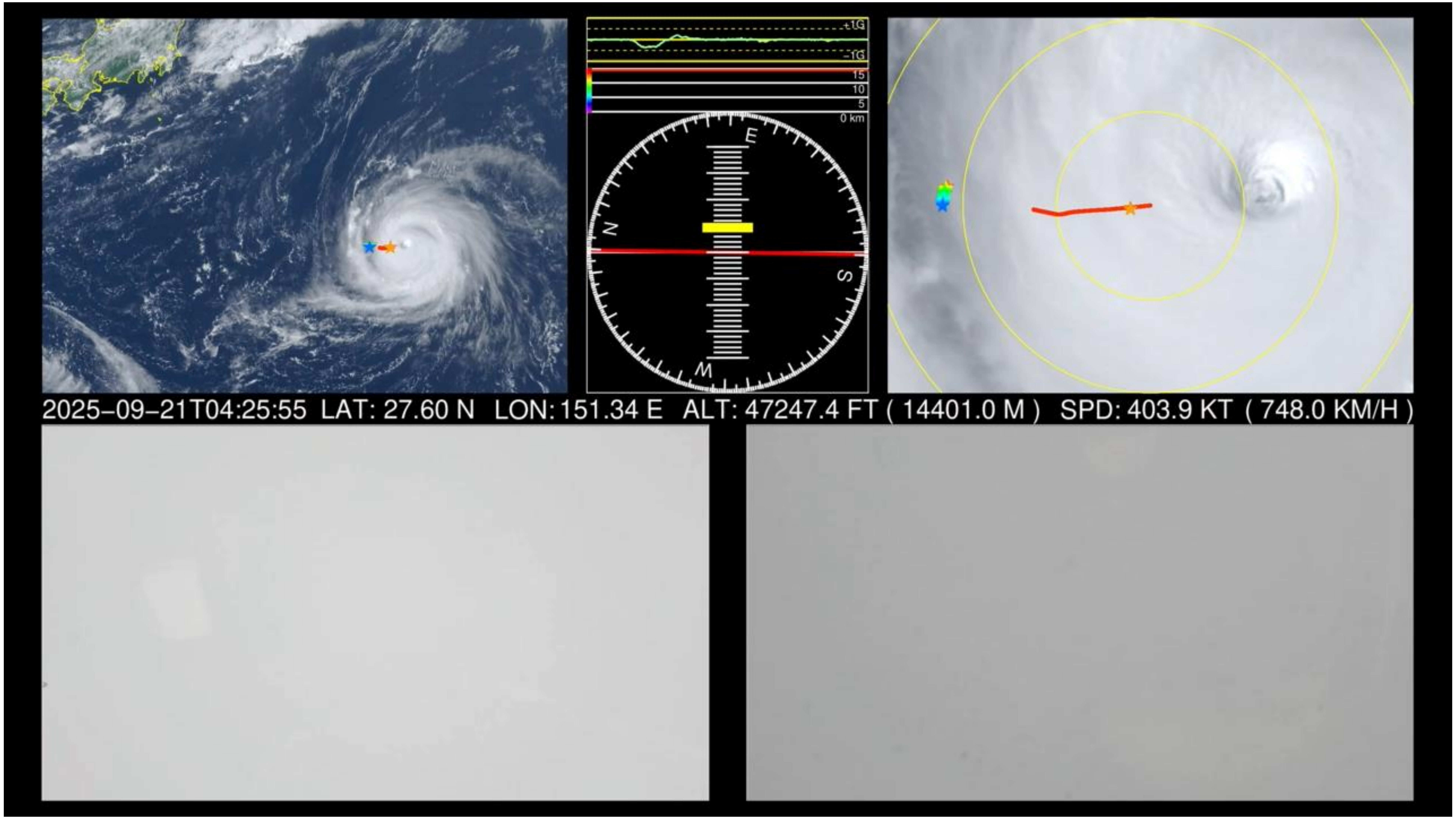
The eyewall-penetrating flight into Typhoon Neoguri on 21 September 2025



Courtesy: M. Kato, Nagoya University

Content

1. History of Japan’s Typhoon Aircraft Missions
2. Technical and Scientific advancement during T-PARCII
3. Brief overview of JMA’s 2025 typhoon aircraft mission
4. Concluding Remarks

Content

History of Japan’s Typhoon Aircraft Missions

<u>Why Aircraft? (Brief History and Japan’s current strategy)</u>

- **The Post-1987 "Gap"**
  - NW Pacific TC analysis has relied mostly on GEO-satellite Dvorak.
  - **But:** Aircraft reconnaissance provides irreplaceable ground truth (Pc, Vmax, structure).
    - *Roles: calibrates Dvorak; improves DA/NWP; advances basic science.*
- **THORPEX Era (~ T-PARC)**
  - Targeted observations delivered forecast benefits-with clear limits.
- **Japan's Strategy (T-PARCII, JMA obs.)**
  - Full-tropospheric, inner-core dropsondes.
  - Focus on inner-core structure/processes that control intensity change in strong TCs.
  - *Note: Data is broadcast through WMO GTS in TEMP format.*

History of Japan's Typhoon Aircraft Missions

~1987 | 2008 | 2016 | 2021 | 2025 | 2030

US aircraft recon.

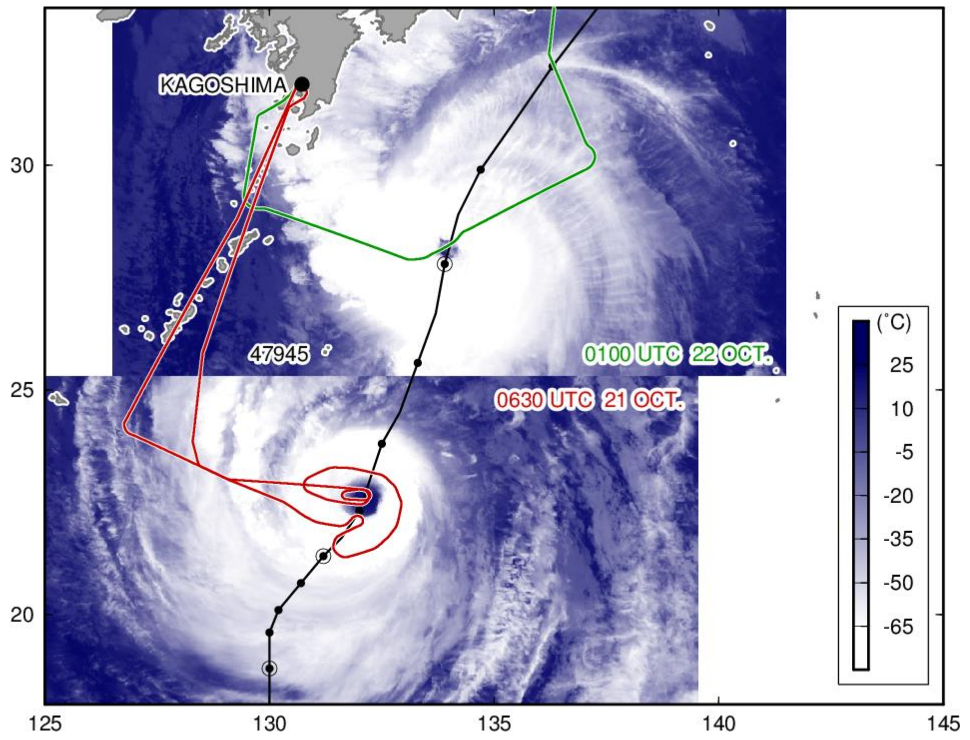
T-PARC (International Campaign led by WMO/THORPEX)

Japanese team flew Falcon 20-E5 (German Aerospace Center, DLR)

T-PARCII (Phase1)

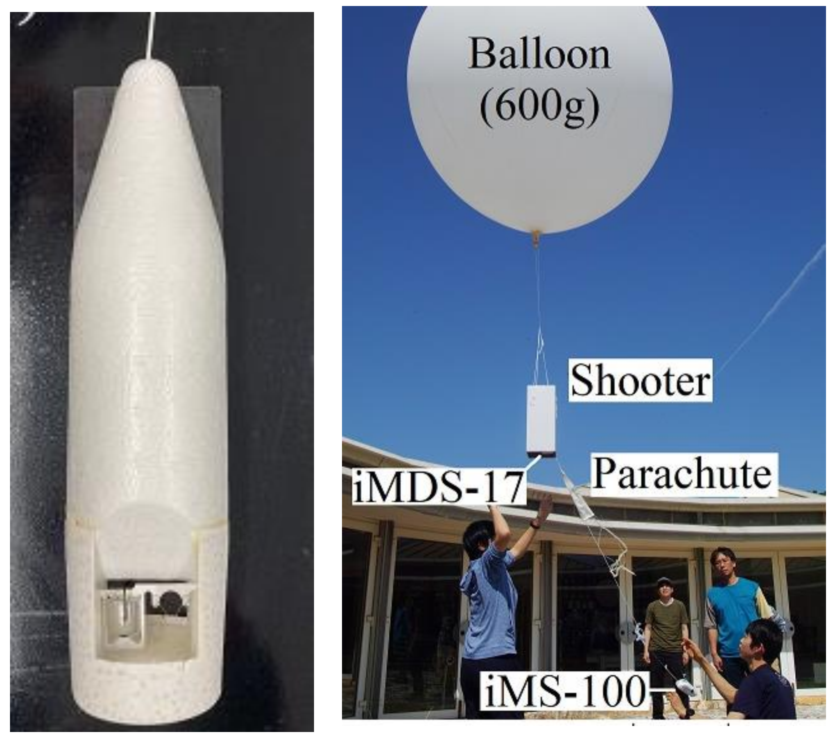
Dropsonde-equipped G-II (Diamond Air Service, DAS)

Eyewall-penetration by a civilian jet



T-PARCII (Phase2)

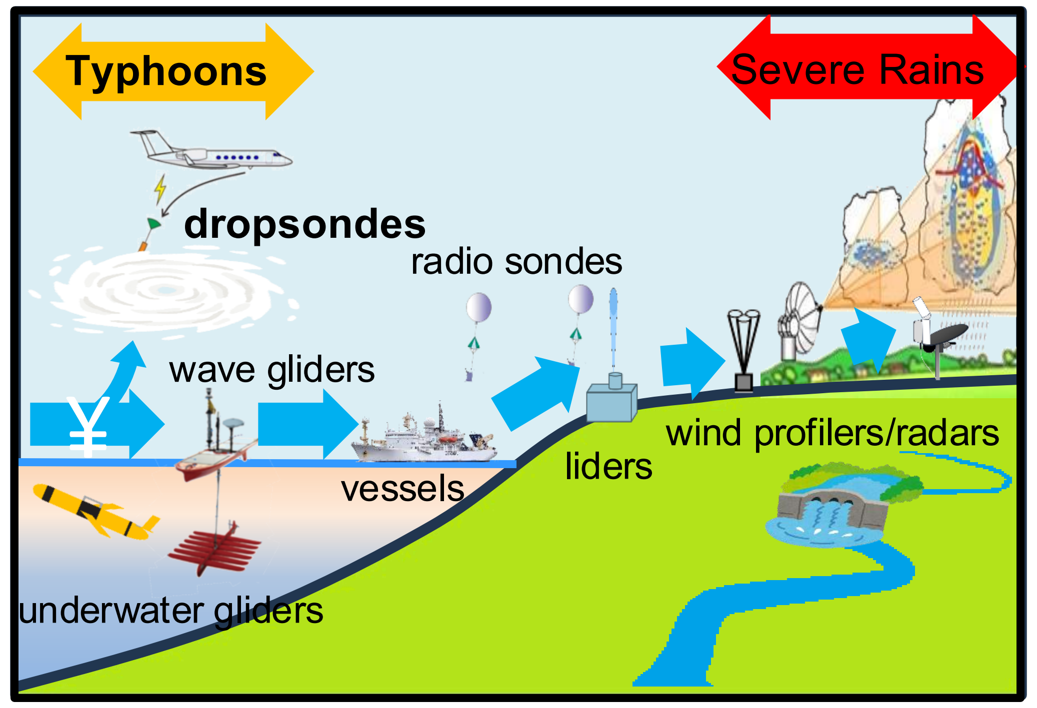
Dropsonde development (Meisei Electronics/Nagoya U.)



JMA's aircraft missions

Dropsonde-equipped G-IV (DAS)

Coordinated observations for Typhoons and severe rain events with space/airborne/land/ocean platforms



In-depth research on TC inner-core evolution

- dynamics, thermodynamics, and impacts on forecasts.

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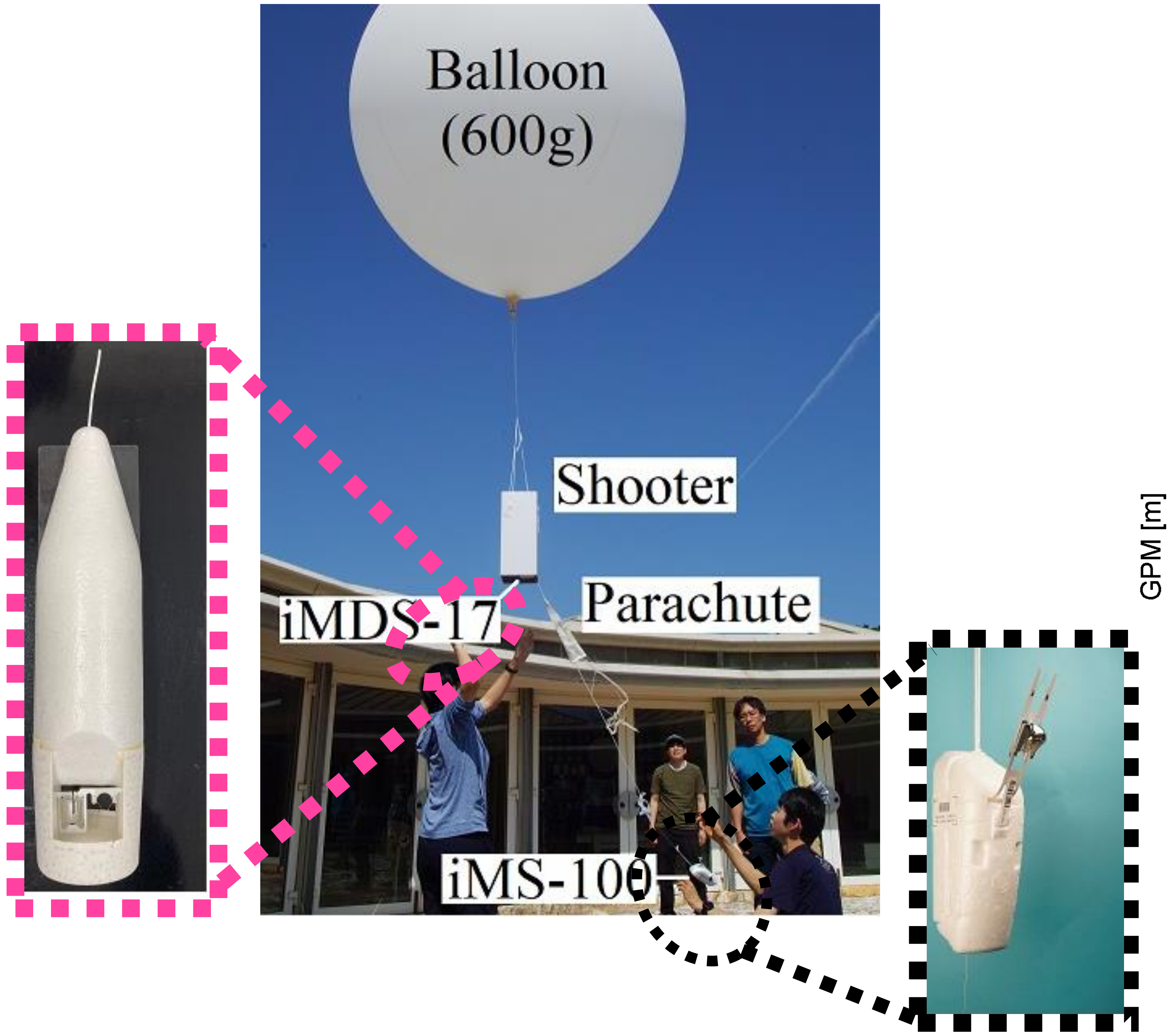
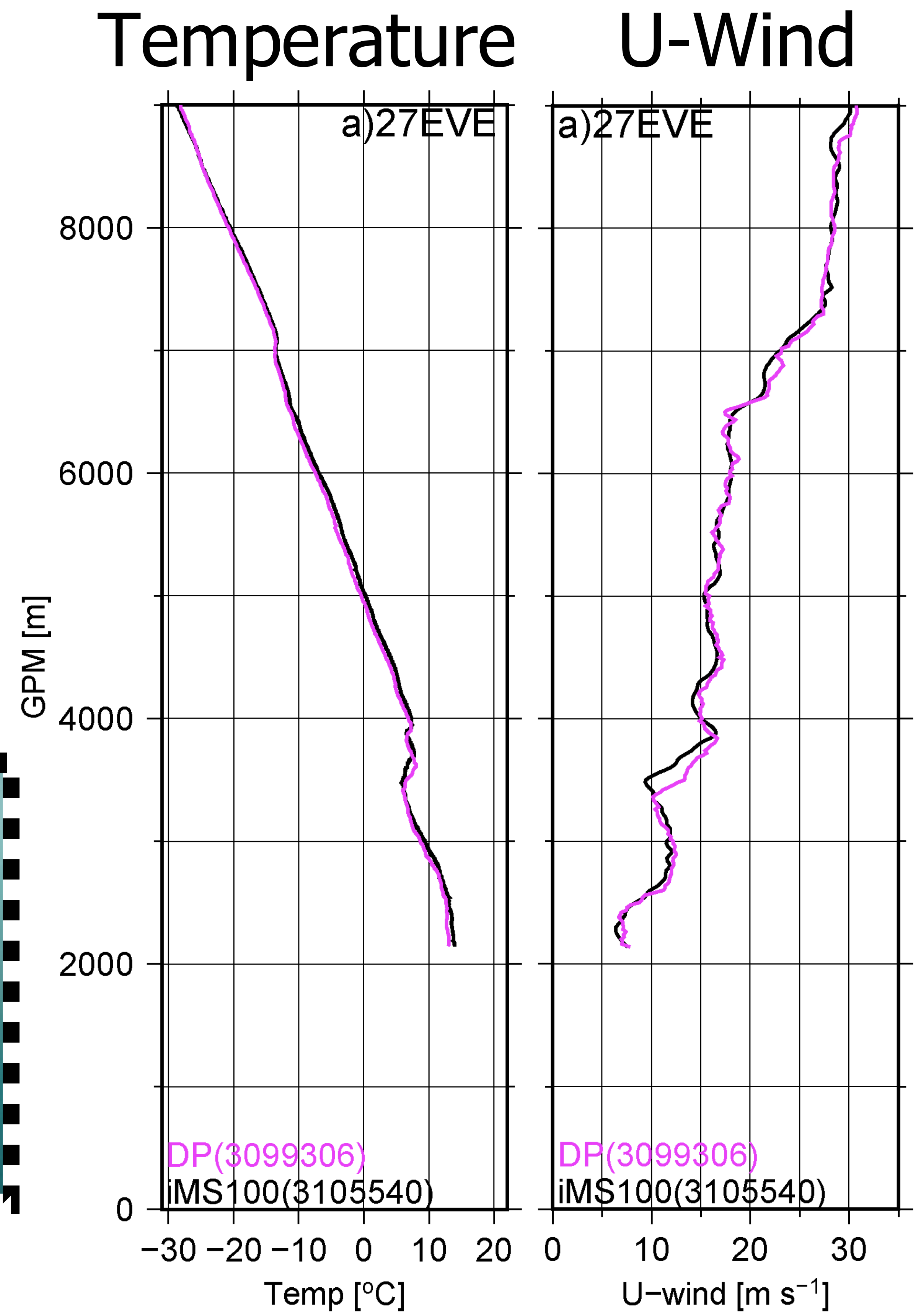
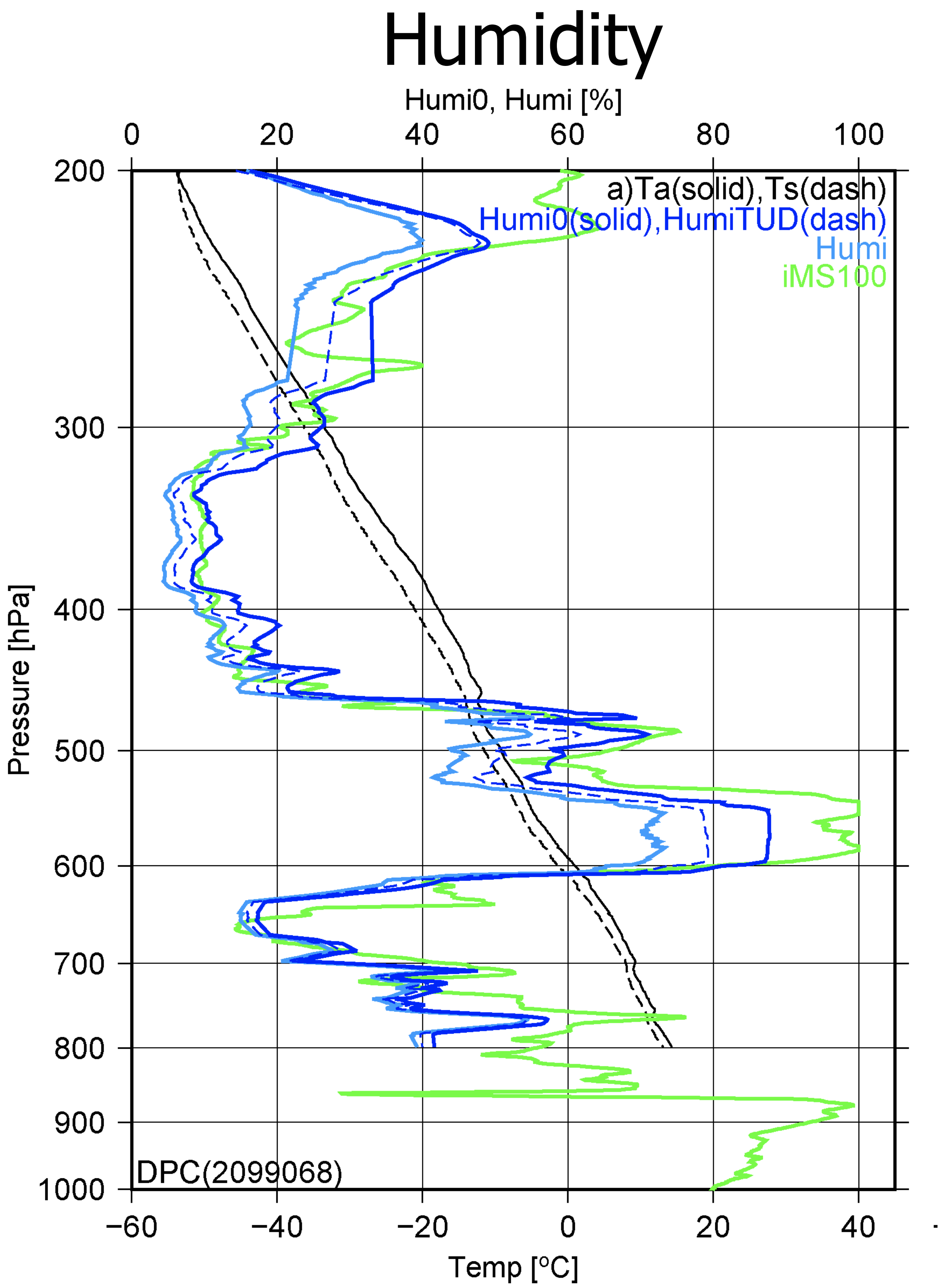
The eye of Typhoon Lan (2017) on 21 Oct. 2017

Courtesy: K. Ito, Kyoto University

Evaluation of iMDS-17 Dropsonde against Operational Radiosonde (iMS-100) (Kanada et al. 2024, SOLA)







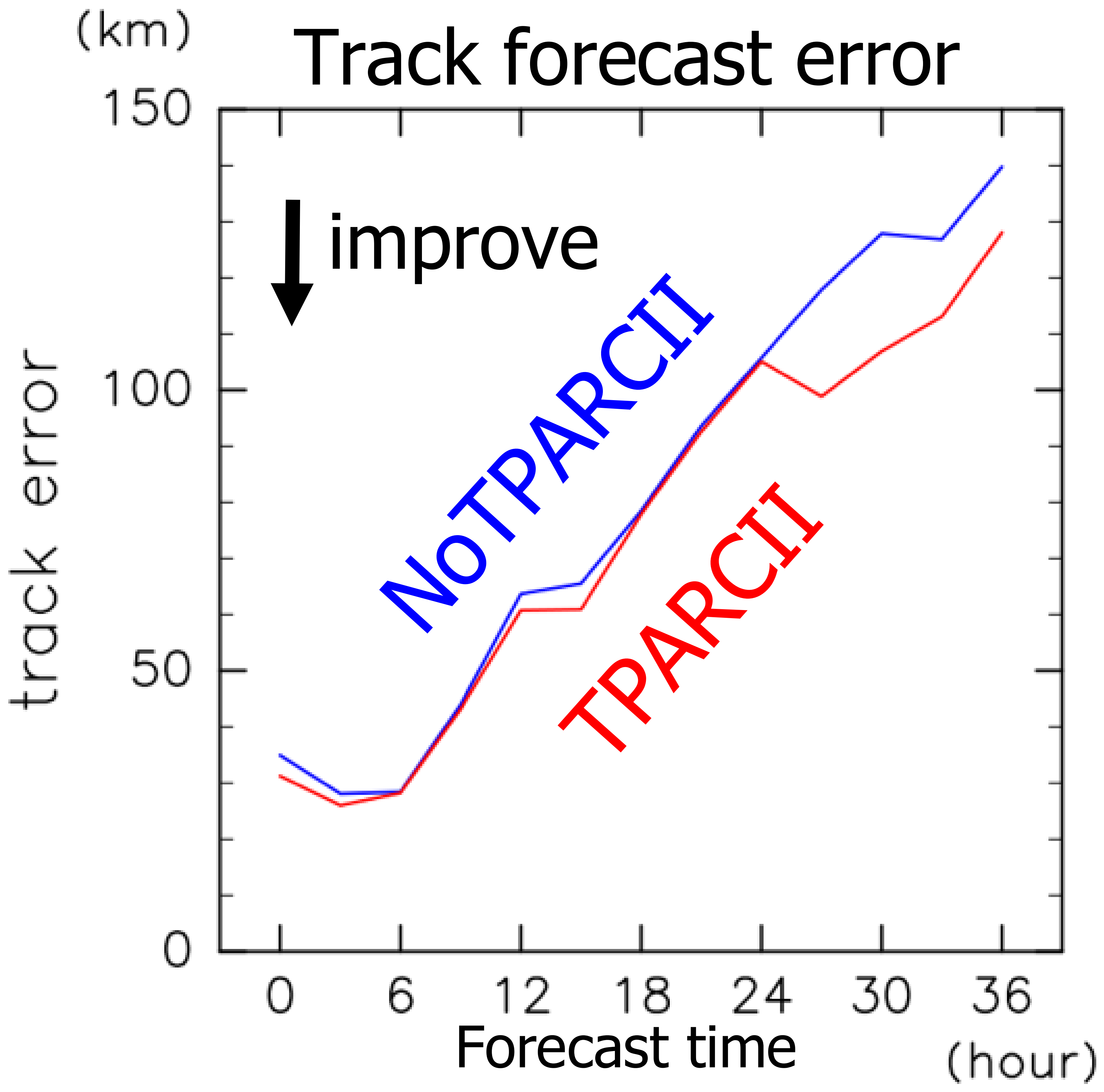
<u>iMDS-17</u>

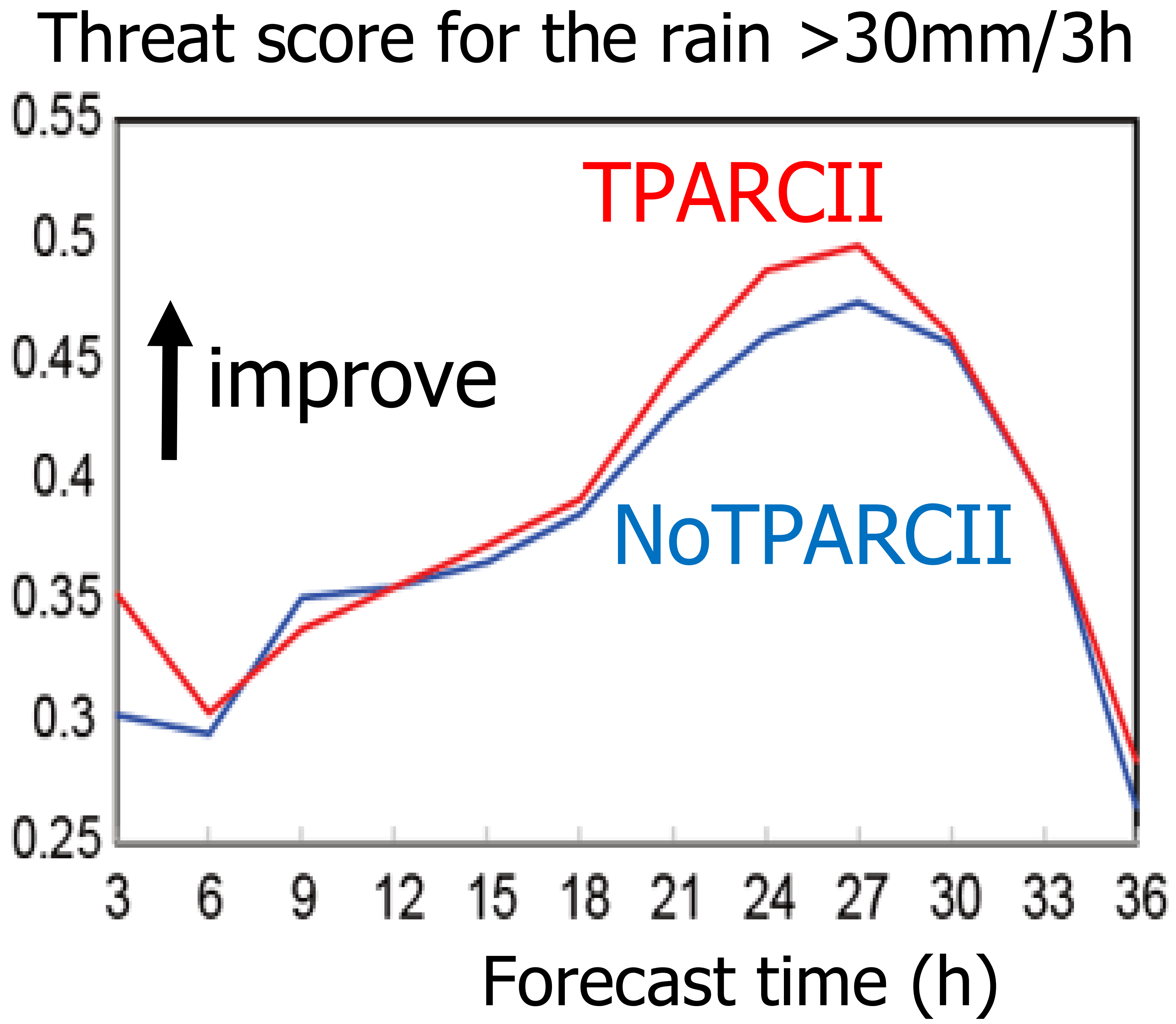
- Parachute-free and lightweight (130 g).
- Jointly developed by Meisei Electronics Co. and Nagoya U for aircraft observations.
- Boosts high-altitude drops success by eliminating parachute failures due to high winds and precipitation.
- Excellent Temperature/Wind agreement with Operational iMS-100 ($\Delta T < 1K$, $\Delta V < 2$ m/s).
- Dry bias detected for wet conditions. Requires RH correction and calibration suitable for descending dropsondes.

  → **This correction was implemented in the 2025 aircraft observations.**

Improved forecasts averaged over 12 cycles for Lan
(Ito et al. 2018, SOLA)

- Assimilating dropsondes with 4DVar system yields a 16% improvement in track forecasts as well as in heavy rainfall forecasts.

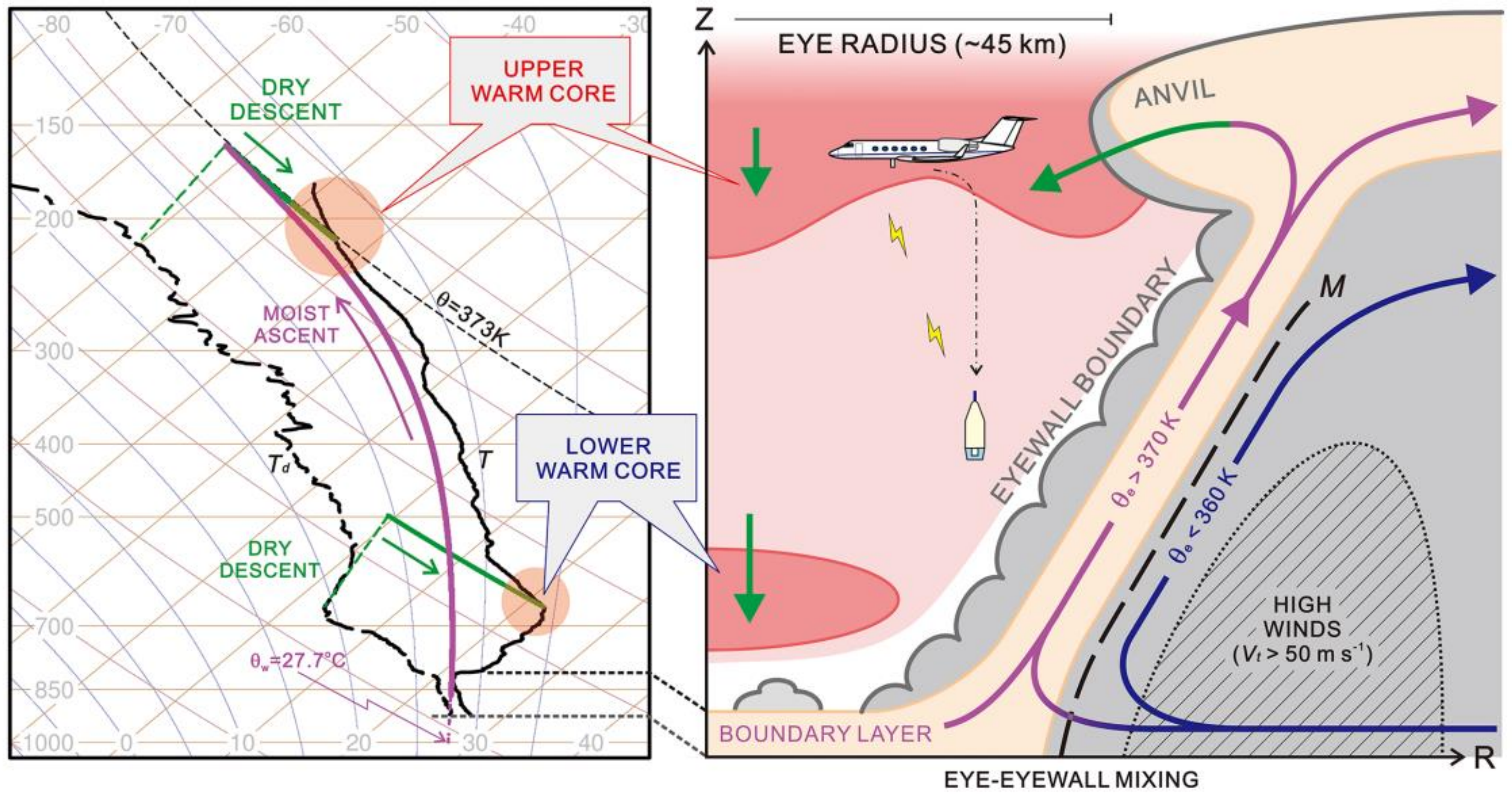




Courtesy: K. Ito, Kyoto University

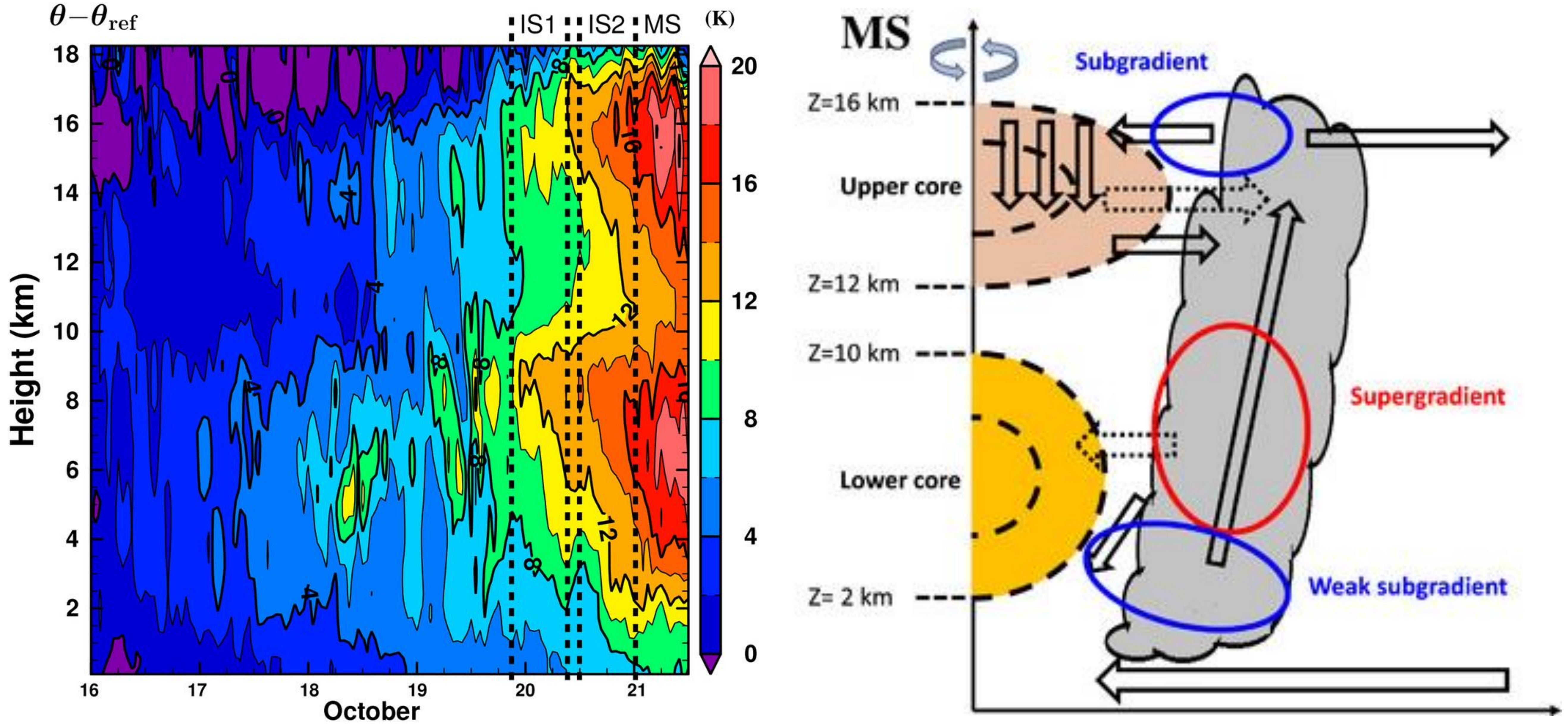
Observations and Simulations of Double warm cores of Typhoon Lan (2017) (Yamada et al. 2021, JMSJ; Tsujino et al. 2021, JAS)

Observed double warm cores of Typhoon Lan (2017)



Yamada et al. 2021

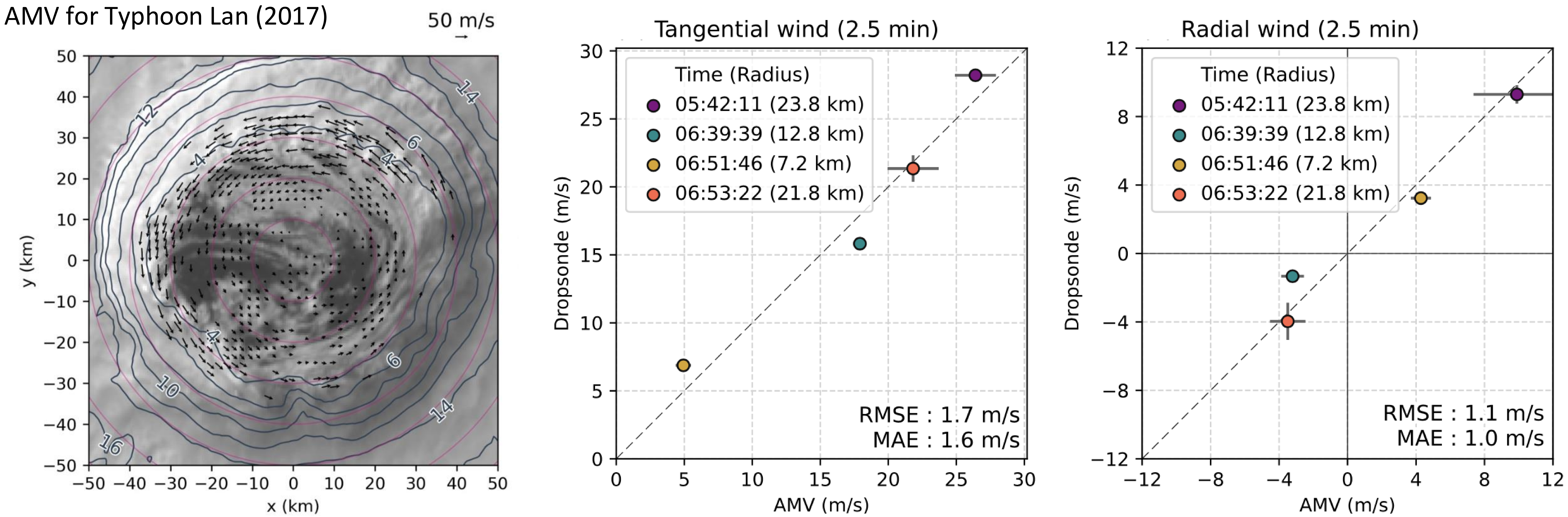
Simulated double warm cores (left) and the schematic of axisymmetric/asymmetric maintenance



Tsujino et al. 2021

- Double warm-core structure was observed.
- Saturation point and parcel-method analysis show that the air in the upper warm core originated in the eye boundary layer and were subsequently transported.
- Simulations of Typhoon Lan (2017) revealed that asymmetric processes (e.g., mesovortices) were crucial for strengthening its lower warm core, playing an important role in intensification.

Development/Application of Atmospheric Motion Vector Derivation Method (Tsukada et al. 2024, JGR)

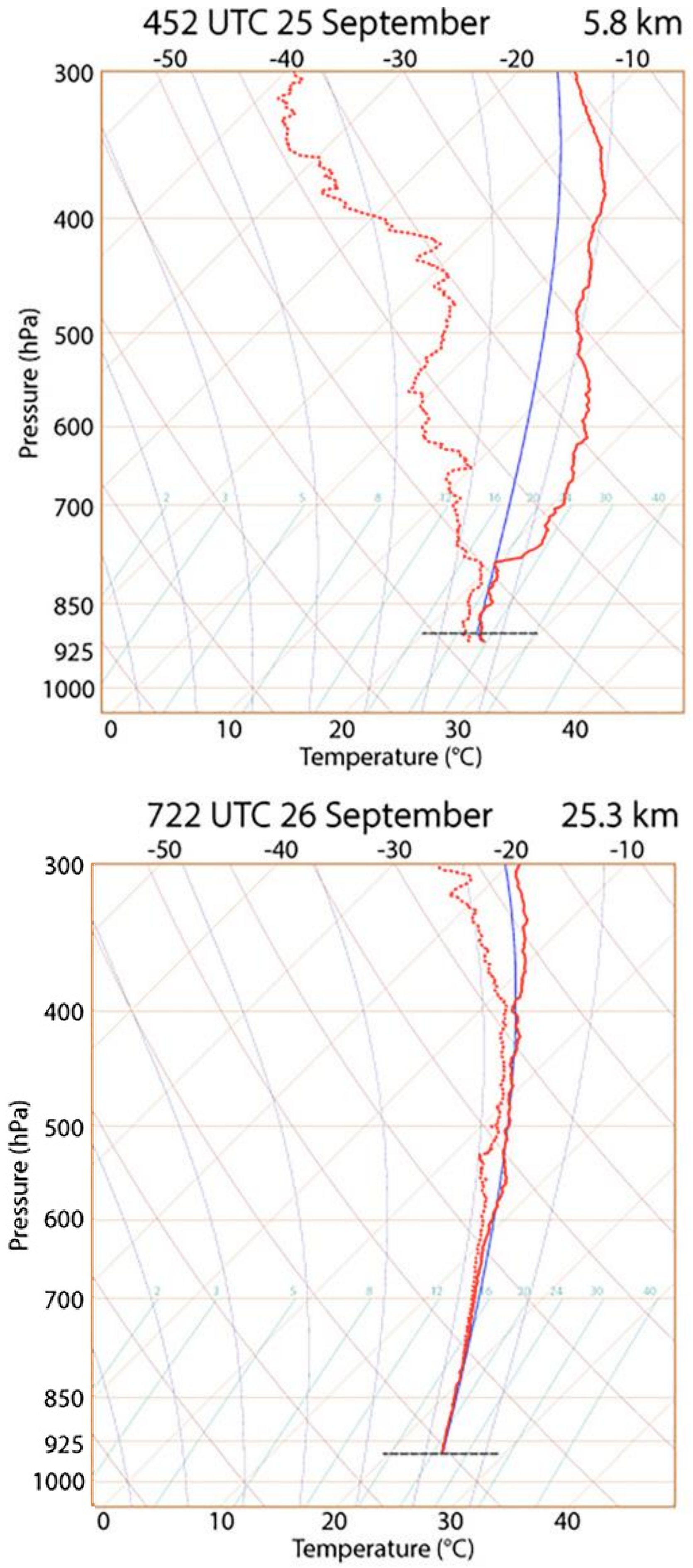


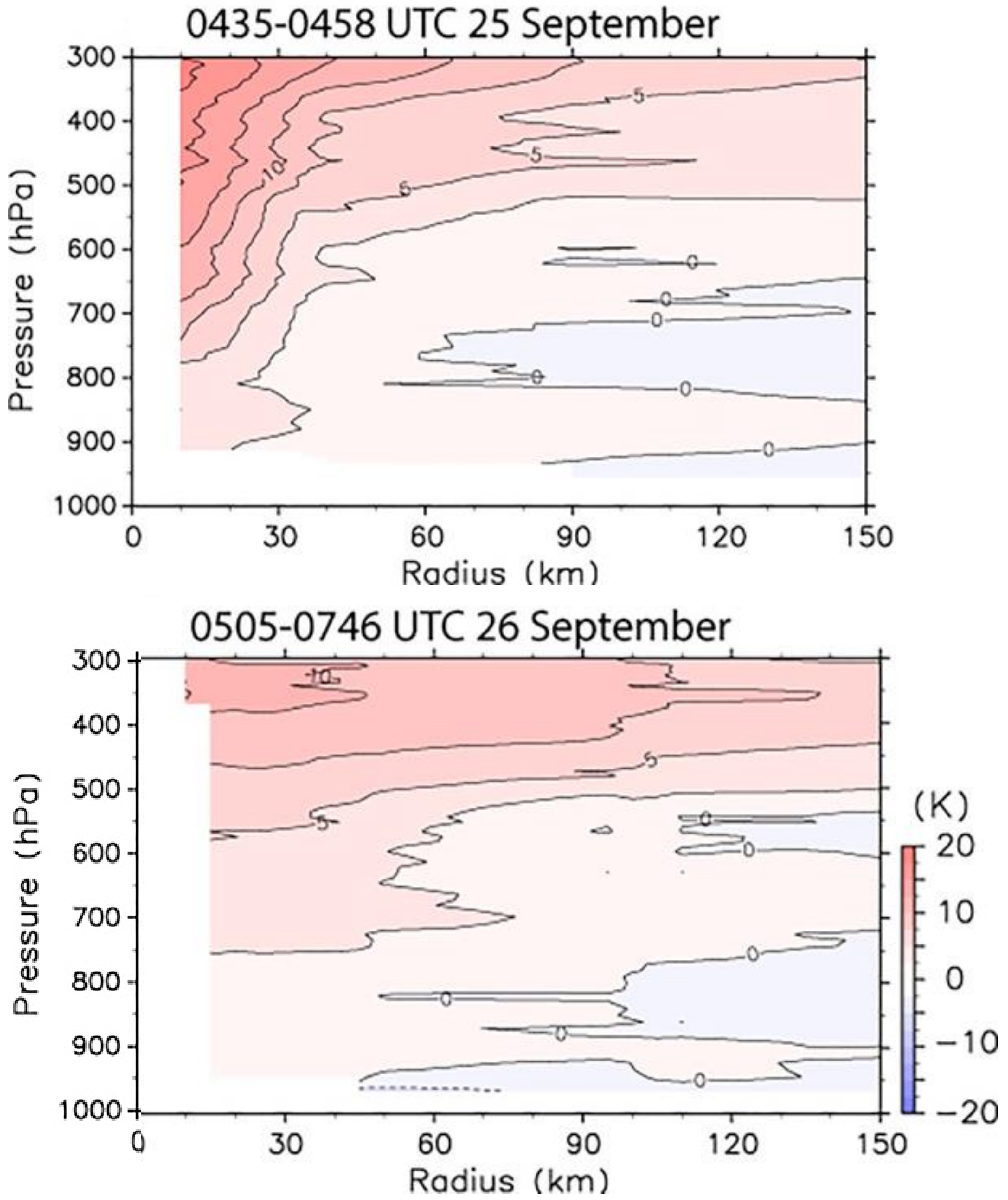
・New AMV method developed for the typhoon eye (Himawari-8 2.5-min), validated against 30-s and dropsonde observations.

・Captured mesovortices that rapidly mix angular momentum, leading to homogenization of the eye's angular velocity.

* A separate study, but with findings highly relevant to T-PARCII.

Structure and Formation Mechanisms of Deep Eye Clouds in Typhoon Trami (2018) (Hirano et al. 2022, JAS)





- Dropsondes captured detailed thermodynamical structure of the deep clouds (DECs) in the eye of Trami.
- Observations and simulations showed that the weakening and outward-moving eyewall resulted in the weak downward forcing in the eye region, which led to conditions favorable for DEC formation.

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Flight observation of Typhoon Neoguri (2025)

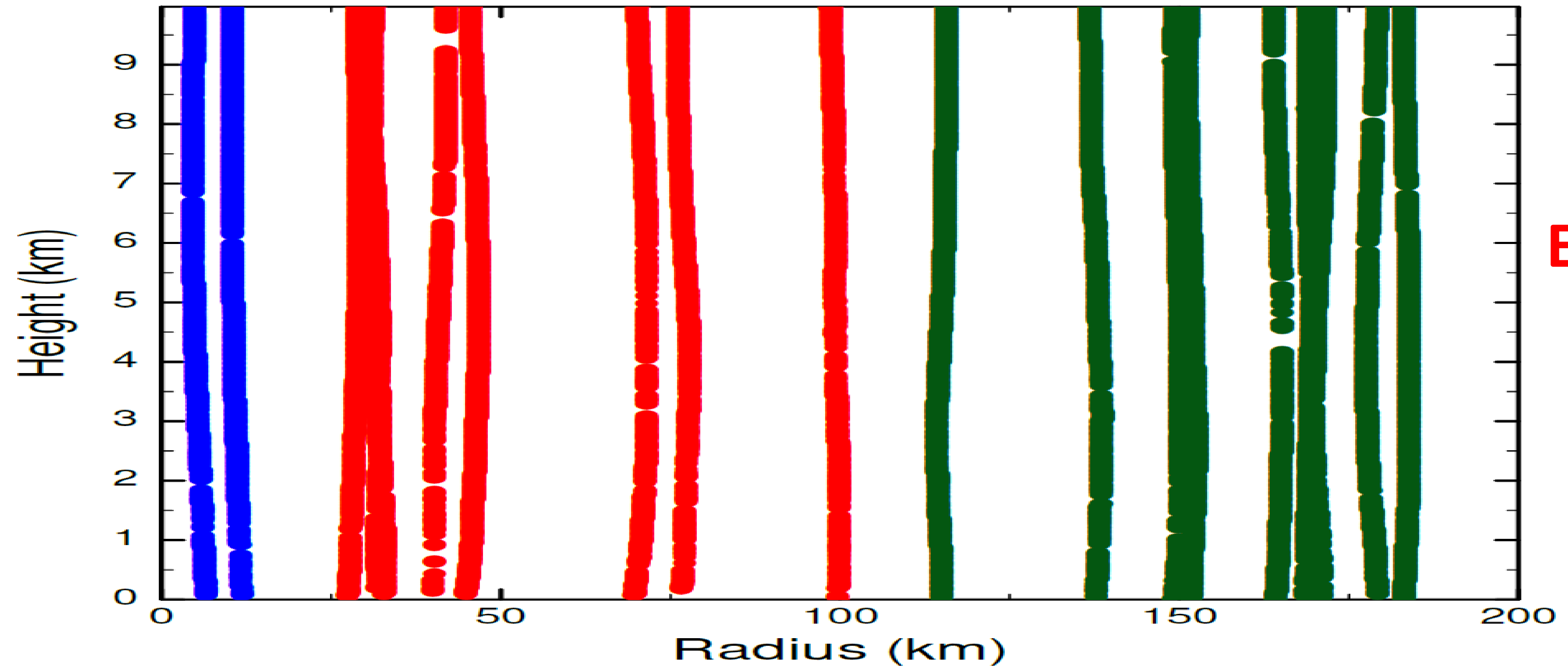
Himawari-9 VIS (Full-Disk / 30-s targeted)

Courtesy: S. Tsujino and U. Shimada, MRI

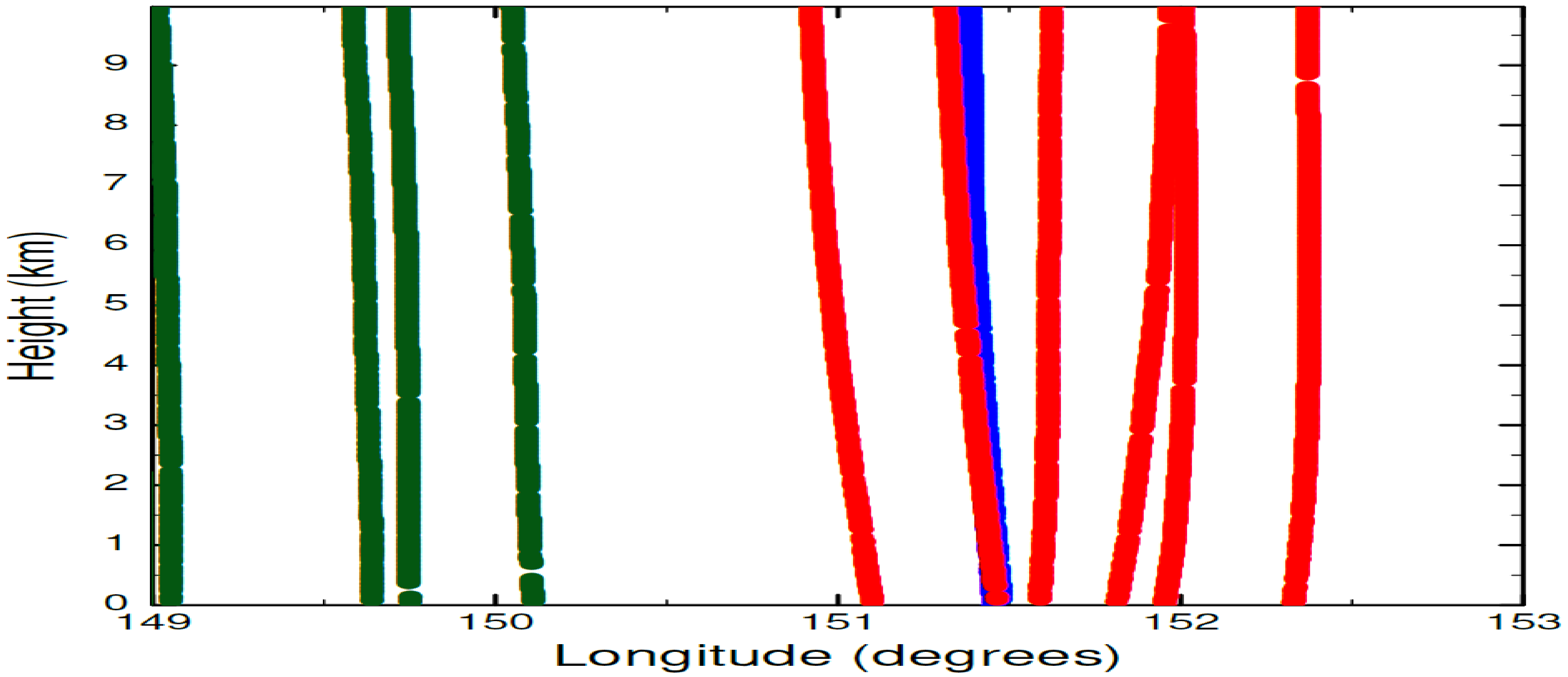
・The humidity sensors of the dropsondes are bias-calibrated on board just before release.
・Dropsondes are then deployed at intervals as short as 5 min (1 min near the eyewall).
* Around 90 percent of drops passed QC and were broadcast to WMO GTS.

Vortex structure from dropsondes

21 Sep. 2025 (JMA mission)

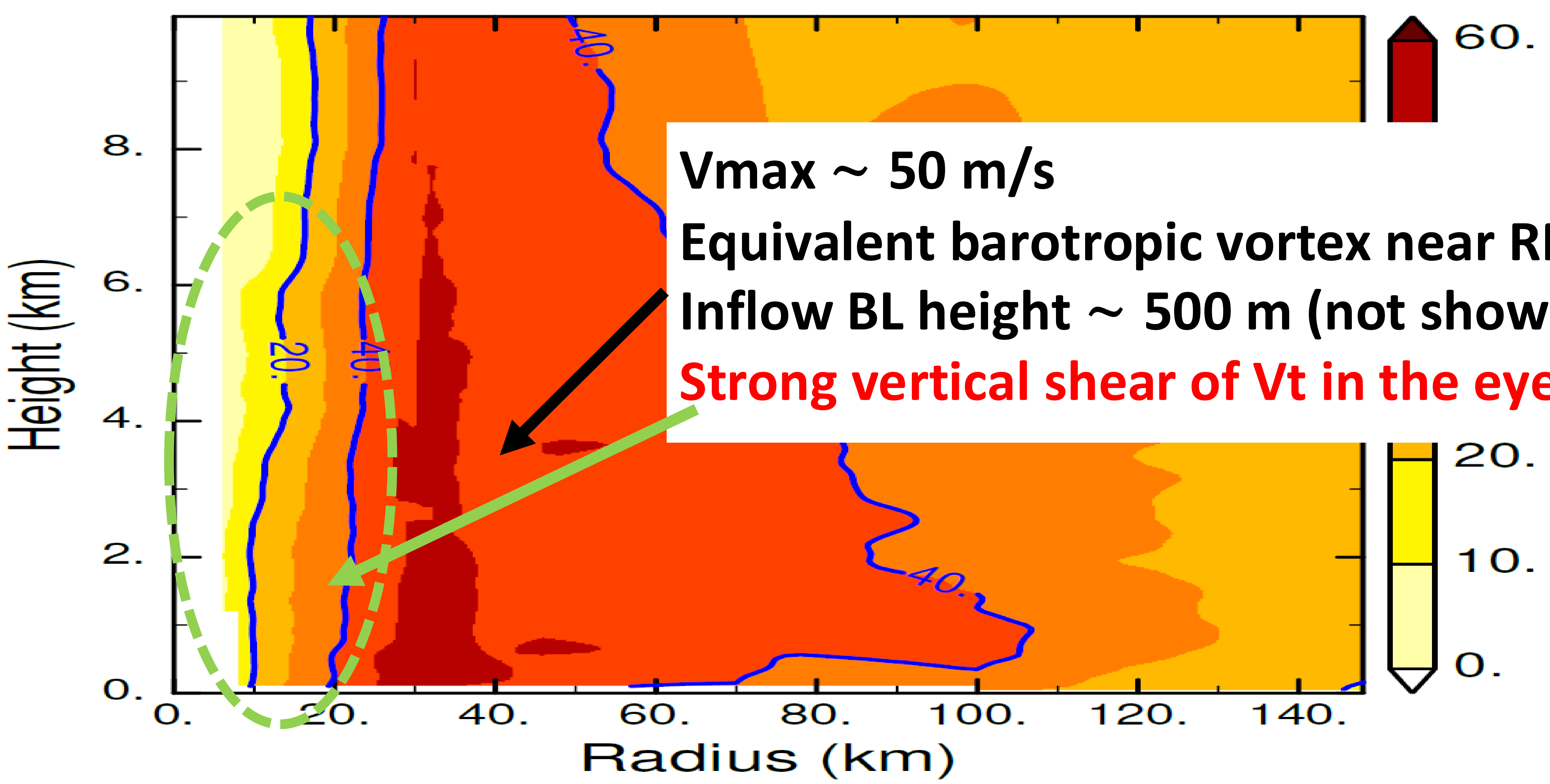


21 Sep. 2025 (T-PARCII)



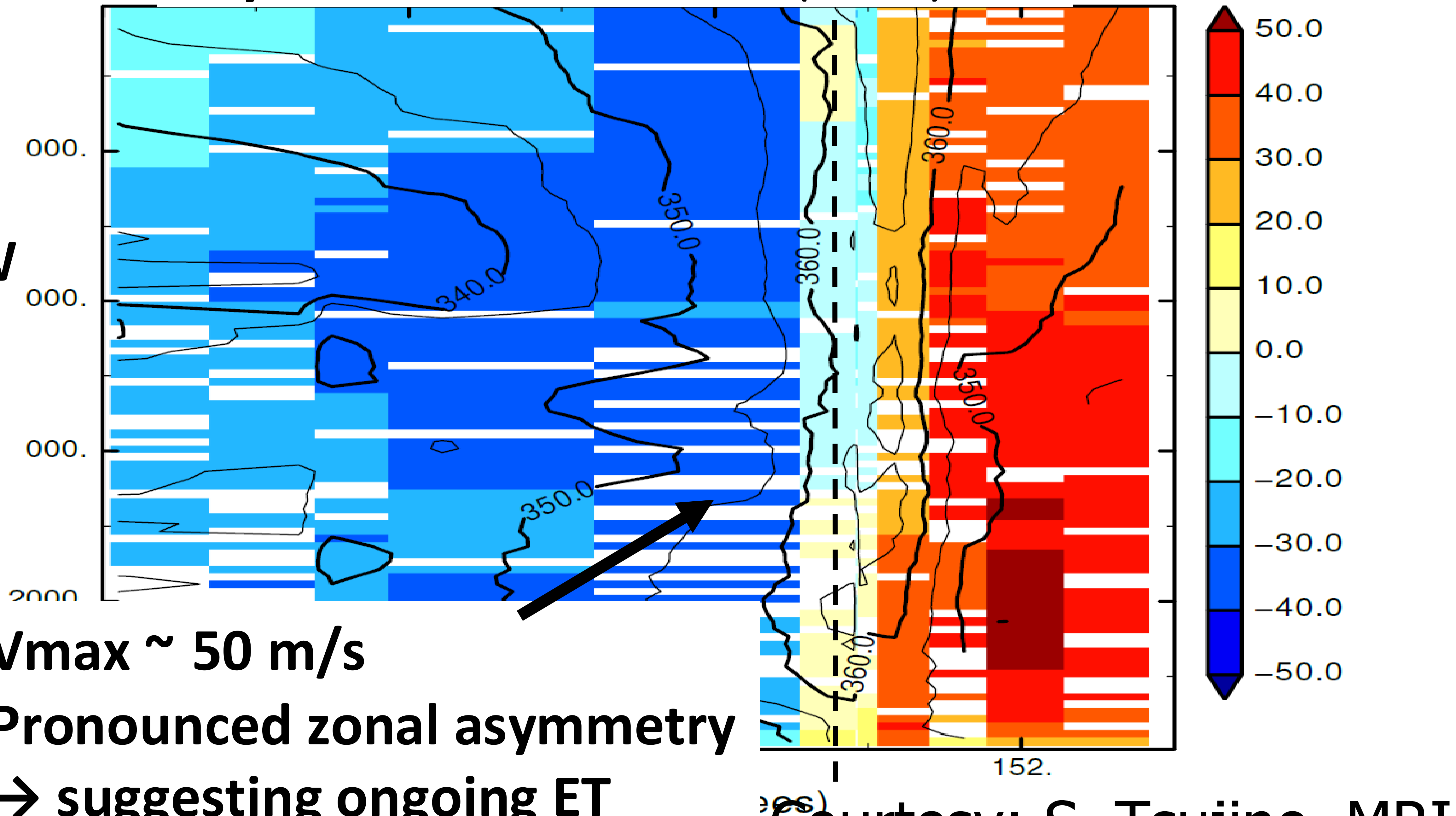
Eye
Eyewall
Outer

Day 1: storm-relative tangential winds (m s^{-1})



Vmax ~ 50 m/s
Equivalent barotropic vortex near RMW
Inflow BL height ~ 500 m (not shown)
Strong vertical shear of Vt in the eye

Day 2: meridional winds (m s^{-1})



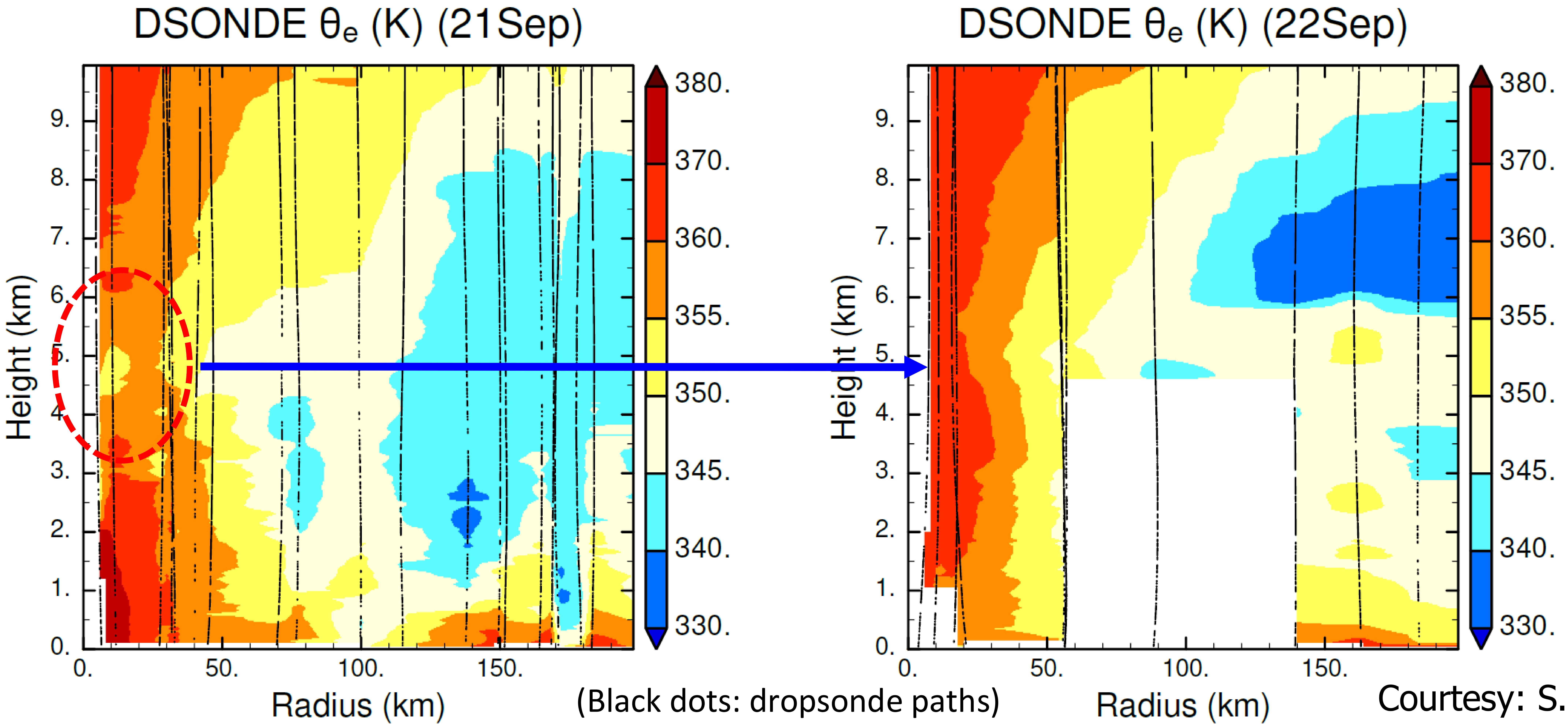
Vmax ~ 50 m/s
Pronounced zonal asymmetry
→ suggesting ongoing ET

Courtesy: S. Tsujino, MRI

Thermodynamic field from dropsondes

The low θe at 4.5-km height in the mature stage *disappeared* during weakening.

→ Suggesting rapid mixing both horizontally and vertically

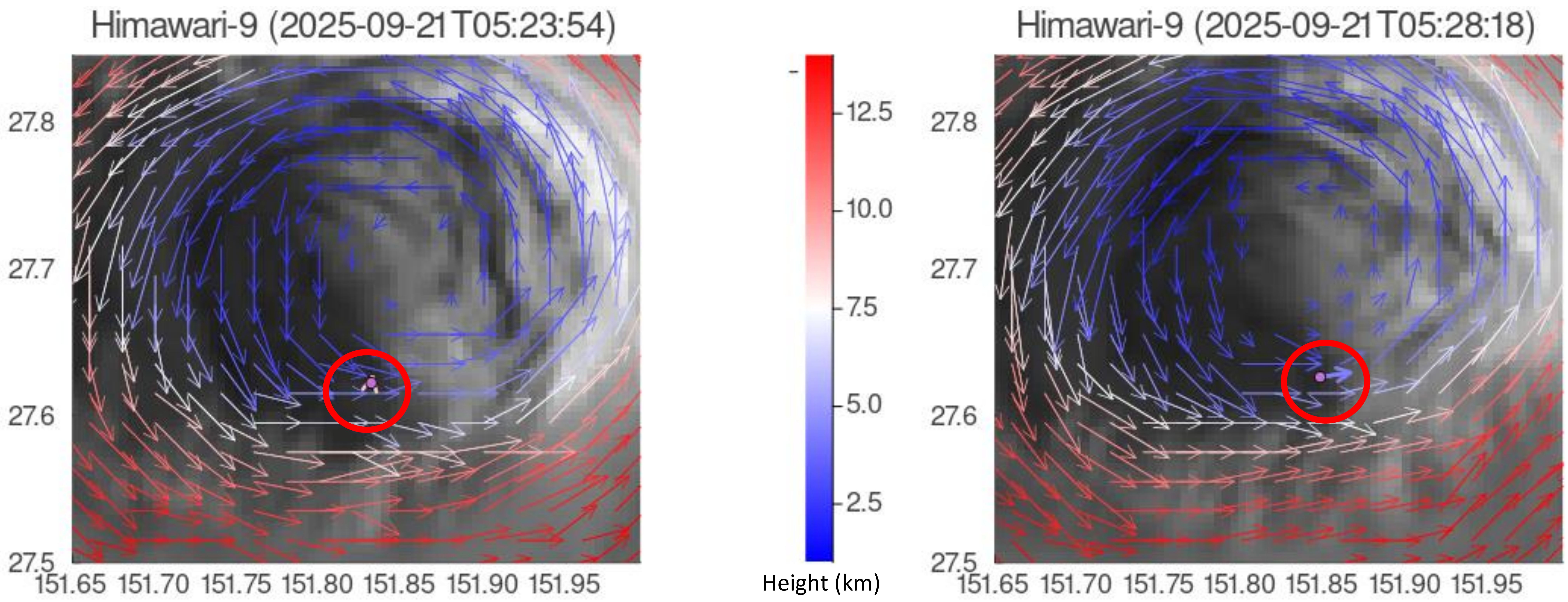


(Black dots: dropsonde paths)

Courtesy: S. Tsujino, MRI

Comparative analysis of AMVs + dropsondes

- Himawari-9 Satellite high-cadence (30-s) targeted observation for Typhoon Neoguri was conducted simultaneously with the aircraft observations.
- AMV-derived winds in the Eye were consistent with dropsonde data.
- The mesoscale PV mixing processes are under analysis.



Thin arrows:
Inner-core AMVs derived from Himawari9 30-sec visible images (cf. Horinouchi et al. 2023), Color indicates height.

Thick arrow and purple dot:
Wind and location of the dropsonde within the eye.

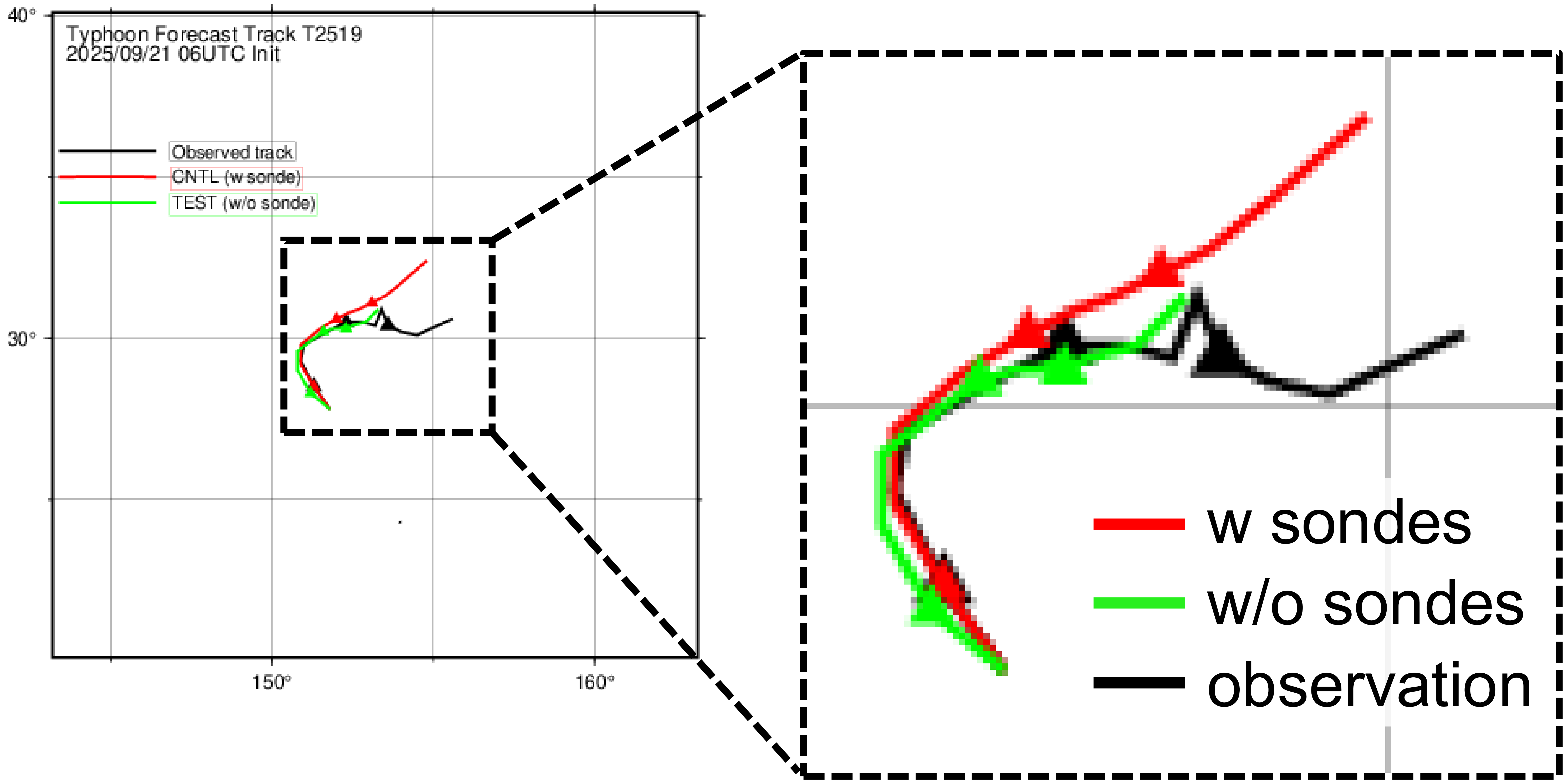
Courtesy: S. Tsujino, MRI

Dropsonde falling in the middle troposphere moved slowly horizontally.

Dropsonde falling in the lower troposphere was *quickly accelerated* horizontally. Its speed is consistent with the low-level AMVs.

Impact of assimilating dropsonde data on Typhoon Neoguri (2025) forecasts

・Slightly positive impact on track forecast, particularly with improved translation speed.



Courtesy: M. Yamaguchi, MRI

*Assimilation experiment with JMA's operational model (GSM)
*Results shown are preliminary

Content

Concluding Remarks

JMA's 4-Year Program (2025-2029)

- Builds on the T-PARCII (2016–2026) legacy (eyewall penetration, parachute-free dropsondes, etc.)
- *Goals for Typhoon Missions:* Study inner-core dynamics/thermodynamics, links to severe-rain events, and improve forecasts.

2025 Mission: Typhoon Neoguri

- Observed Mature (JMA) and Weakening (T-PARCII) stages with the DAS G-IV.
- Full-tropospheric inner-core data at high temporal resolution (down to about ~ 1-min).
- Data disseminated via WMO GTS.

Future Directions and Collaboration

- WNP benefits from diverse observation efforts (ground, radar, aircraft, satellite).
- All contributions are vital for advancing regional DRR and basic science.
- Let's continue strengthening our data exchange and collaboration, working together for regional safety and scientific progress!

References

- Ito et al., 2018: Analysis and forecast using dropsonde data from the inner-core region of Tropical Cyclone Lan (2017) obtained during the first aircraft missions of T-PARCII, SOLA, 14, 105-110, doi:10.2151/sola.2018-018.
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