# Evaluating Moisture Representation in ERA5 Reanalysis: Insights from Tropical Cyclone Aere During the PRECIP 2022 Field Campaign

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## Motivation

- ERA5 Reanalysis is a widely used tool for research and operational applications, particularly over areas such as the tropics and ITCZ where there are limited observations.
- Therefore, it's important to ensure the accuracy of ERA5 data.
- Relative humidity, horizontal and vertical winds, and temperature parameters were analyzed between PRECIP Field Campaign Data and ERA5 Reanalysis to determine potential bias.

## Objectives

- How well does ERA5 represent the background state of the northern equatorial western Pacific during the 2022 PRECIP campaign?
- What potential errors or biases arise from these discrepancies?
- What factors contributed to Aere, a weak tropical depression, generating excessive rainfall over the western region of Japan in the absence of upper-level synoptic support?

## Taiwan Radiosonde Composites vs ERA5 Reanalysis

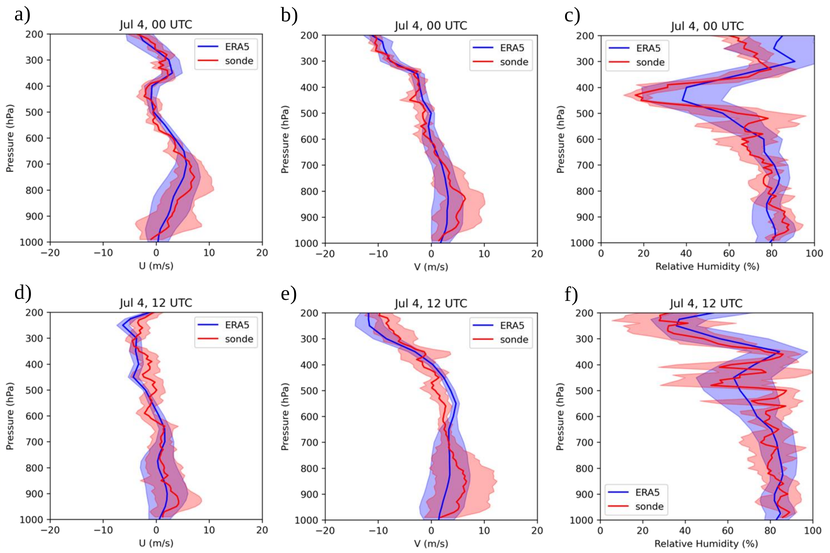
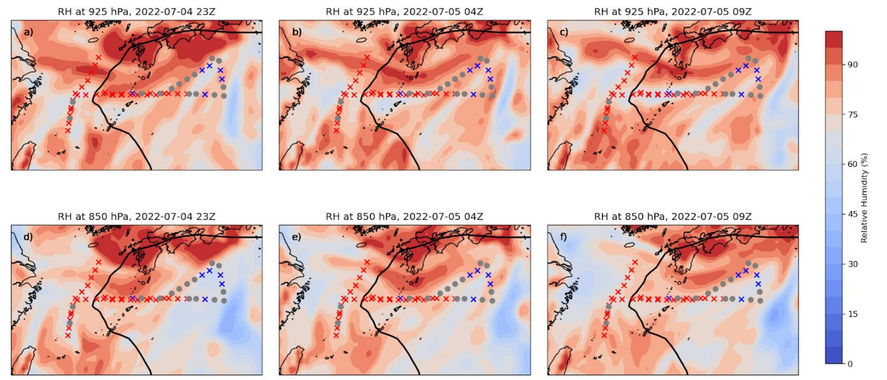
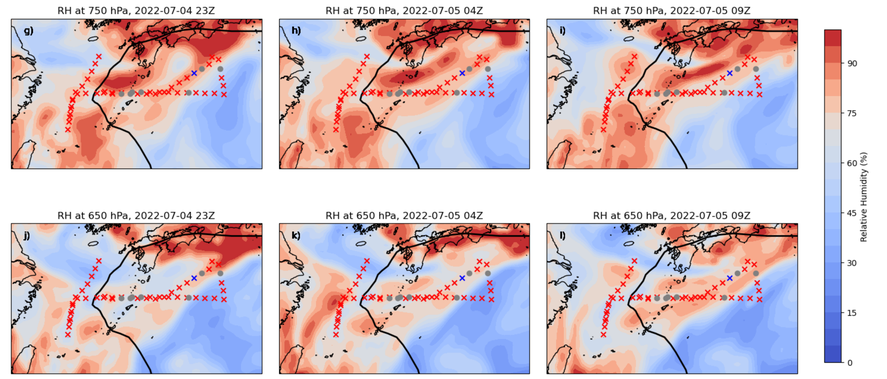



Figure 1: Composite mean and standard deviation analysis for five Taiwan radiosonde stations at every pressure level. The top row (a-c) is for 07/04/2022 00Z, while the bottom row (d-f) is for 07/04/2022 12Z. The first column (a, d) analyzes zonal winds, the second column (b, e) analyzes meridional winds, and the third column (c, f) analyzes relative humidity. The ERA5 mean line is blue, and the radiosonde mean line is red with corresponding shadings denoting standard deviation at each pressure level for a given variable.

## ERA5 vs T-PARCII Dropsonde Low-Level Relative Humidity




## ERA5 vs T-PARCII Dropsonde Mid-Level Relative Humidity




Close estimation
Overestimation
Underestimation

Figure 2: Relative humidity for top row (a-c): at 925hPa, second row (d-f): at 850hPa, third row (g-i): at 750hPa, and bottom row (j-l): at 650hPa for 07/04/2022 00Z, 07/05/2022 04Z, and 07/05/2022 09Z respectively. Accuracy estimation points overlaid compare observational TPARCII dropsonde data to ERA5 estimations for low-level (975hPa-850hPa) and mid-level (850hPa-650hPa) RH, Aere's track is shown as a black line.

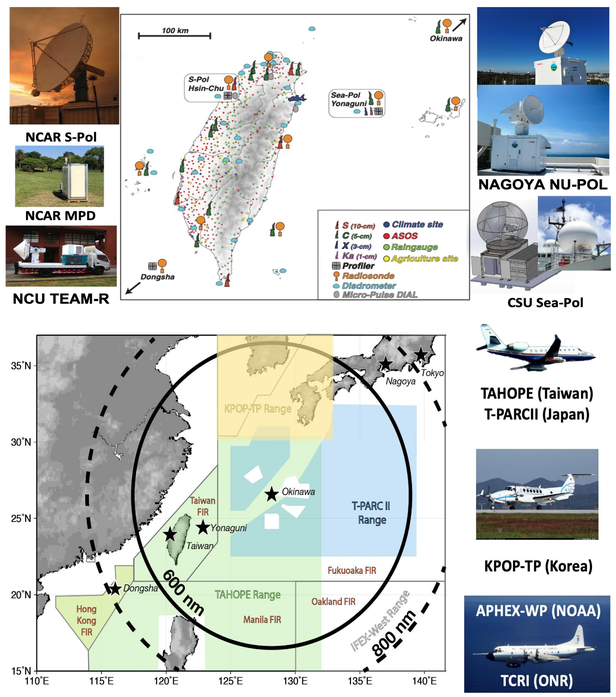
It is important to note that the T-PARCII dropsonde data may have technical issues and dry bias.

## PRECIP Campaign 2022

- Taiwan and the North Pacific region have complex terrain, a moisture-rich environment, a dense observational network, and a high frequency of heavy rainfall events (PRECIP, 2022)

- Convectively coupled mode events are common in the Taiwan region (MJO, BSISO, SW Monsoonal Flow, frequent easterly waves and TDs) (Serra, Rutledge, Chudler, Zhang, 2023)

- Radiosondes from five upper-air stations in Taiwan and dropsondes from Japan (T-PARCII) and Korea (KPOP-TP) are utilized




## No Apparent Upper-Level Synoptic Support

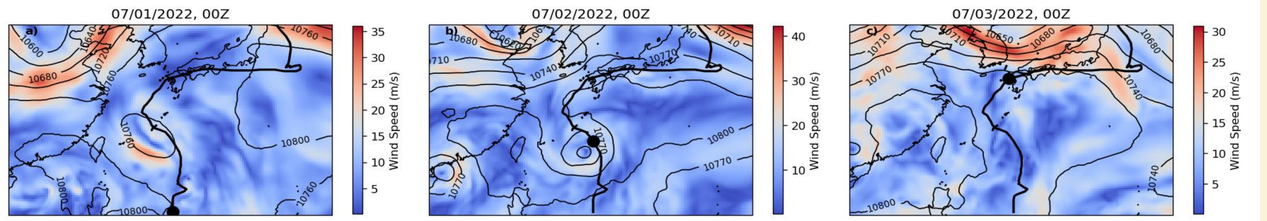



Figure 3: Upper-level 250hPa winds peed and 250hPa geopotential height contours for (a) 07/01/2022 00Z, (b) 07/02/2022 00Z, and (c) 07/03/2022 00Z respectively as TD Aere approaches Japan and TC Chaba is seen upstream in the bottom left. Aere's track and center location are shown with a black line and dot.

## Conclusion

- Composite analysis of Taiwan radiosondes in Figure 1 reveals that ERA5 slightly underestimates low-level moisture, potentially biasing IWV and IVT calculations. ERA5 often displays "top-heavy" behavior in mixed convective scenarios, such as tropical systems, overestimating high-level cloud fraction while underestimating mid and low-level humidity; this pattern is reflected in Figure 1 (c, f) (Serra, Rutledge, Chudler, Zhang, 2023).

- ERA5 generally overestimates moisture at all levels compared to T-PARCII dropsondes, except in the eastern half at low-levels (925hPa, 850hPa) in Figure 2 (a-f), where it shows closer estimates or slight underestimations. Potential dry biases in T-PARCII dropsondes may play a part in this widespread overestimation pattern.