

Morphology and Dynamics over the Monsoon Gateway and Rain Shadow Regions: Insights from Long-Term Radar Analysis and Reanalysis

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Theme 4 : 148

Introduction

- ❖ Monsoon convection plays a crucial role in regional climate dynamics, influencing precipitation patterns, radiation budget, and tropospheric-stratospheric exchange processes.
- ❖ Understanding the morphological, dynamical, and microphysical characteristics of monsoon convection is crucial, as the influence of the southwest monsoon varies significantly across India

Over the Past

- ❖ A comprehensive statistical analysis on the CS at different spatial and temporal scales is required for cloud-resolving model simulations and parameterization.
- ❖ Sindhu and Bhatt,(2018) - Hyderabad, Nagpur, Patiala, Kolkata-2013
- ❖ Utsav et al. (2017)- Mahabaleshwar-2014
- ❖ Jha et al. (2023)- Monsoon Trough -2007-2017

Missing ????

- ❖ An assessment of comprehensive morphology between the Gateway and Rain-Shadow regions
- ❖ Influence of background meteorology on radar derived convective storms

Objectives

- ❖ What is the storm morphology over the gateway and rain-shadow regions?
- ❖ Are there any similarities or differences in the storm properties?
- ❖ How does the storm interact with large-scale atmospheric conditions?

Data and Methodology

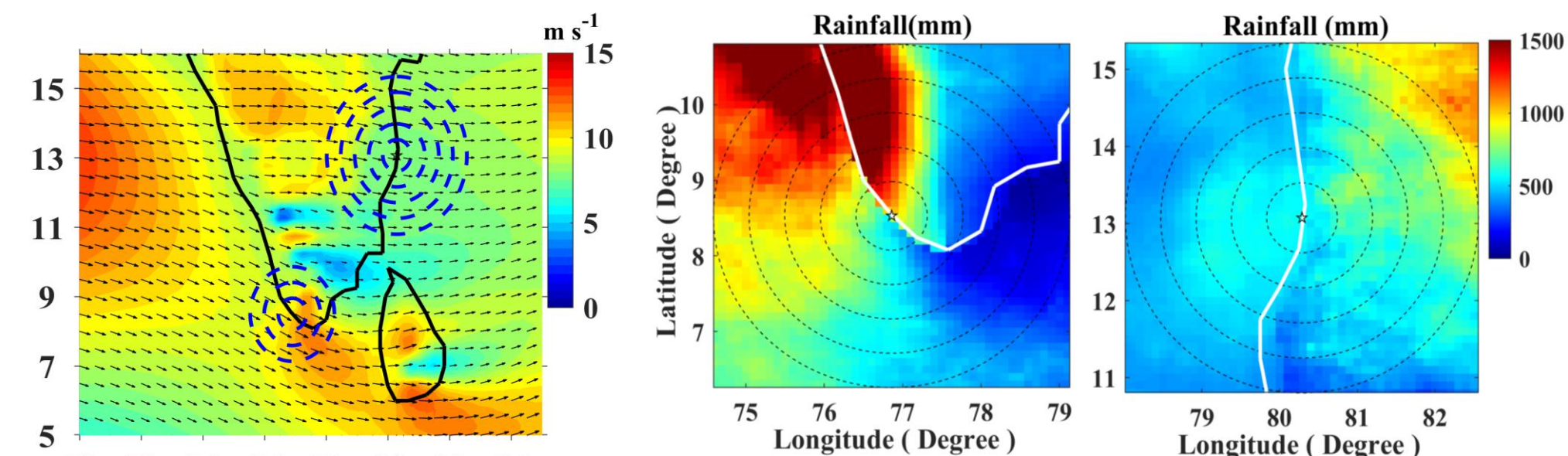


Fig 1 Zonal winds with direction during June-September averaged from 2017-2021. The concentric circles indicate the radar coverage area. Mean rainfall map over south-west and south-east

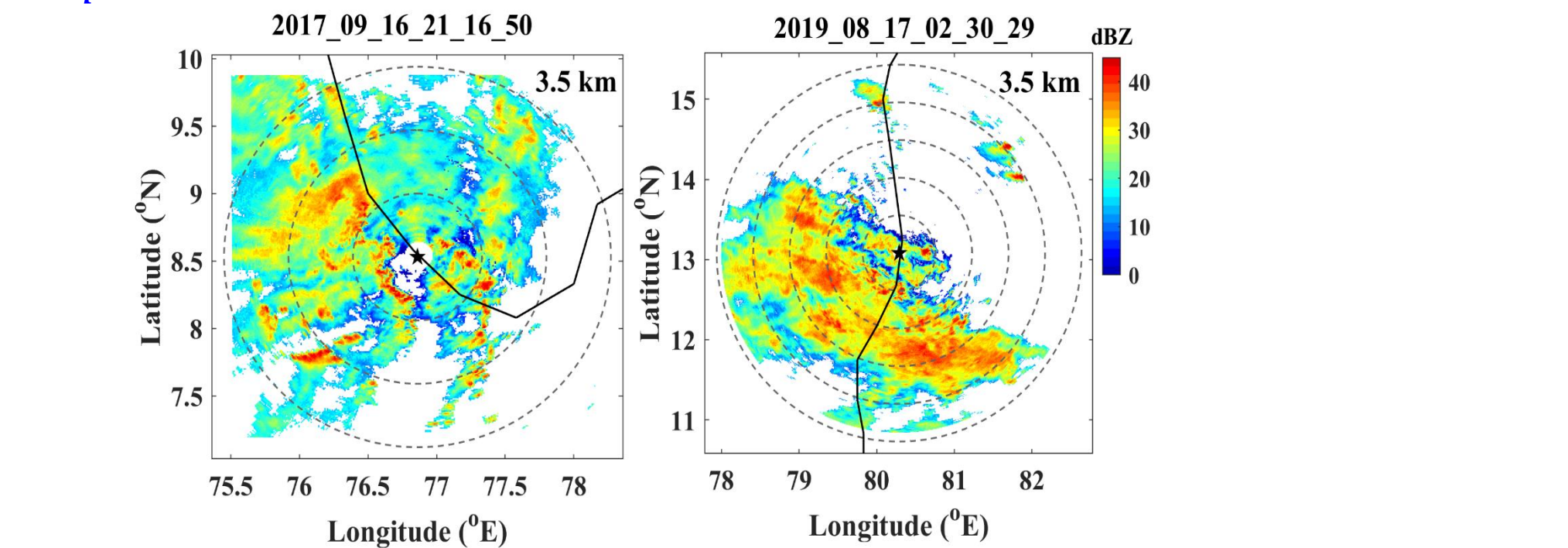


Fig 2 CAPPI of reflectivity at 3.5 km over Thumba (left panel), and Chennai (right panel)

- ❖ DWR-Chennai (13.07, 80.28),(S-band – Range:250 km), (2017-2019)
- ❖ DWR-Thumba (8.5, 76.9), (C-band – Range:150 km), (2017-2023)

Results and Discussion

A convective storm (CS) is detected as a continuous region of 35 dBZ occupying a volume of 30 km³ using (TITAN) developed by Dixon and Wiener (1993).

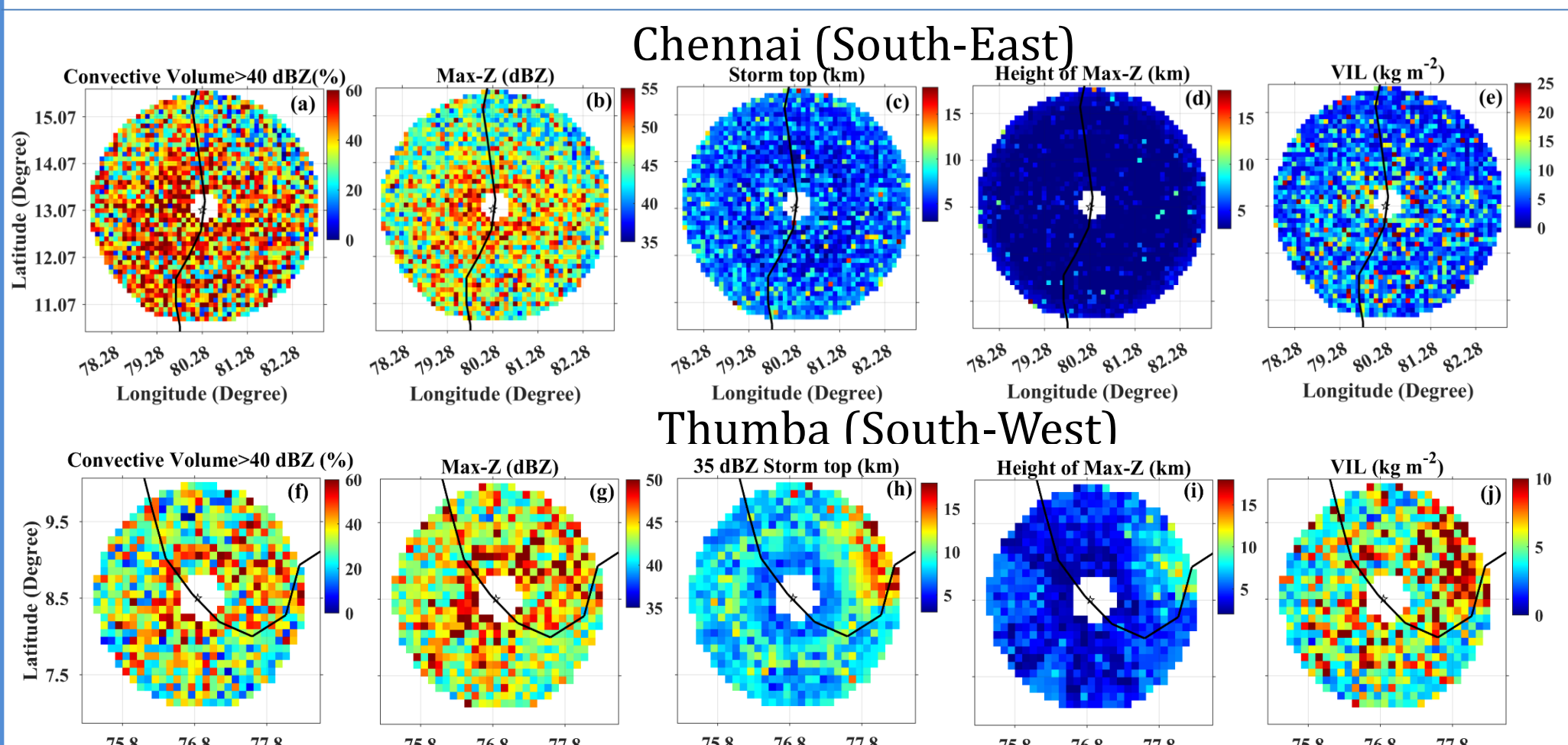


Fig 3 Spatial distribution of (a) % occurrence of convective volume > 40 dBZ, (b) Eccentricity, (c) Max-Z, (d) Storm top, (e) Height of Max-Z, and (f) VIL of the convective storms from 2017-2023.

- ❖ Storms are more intense over south-eastern compared to south-western part of India
- ❖ The storm top is high over the south-west compared to south-east

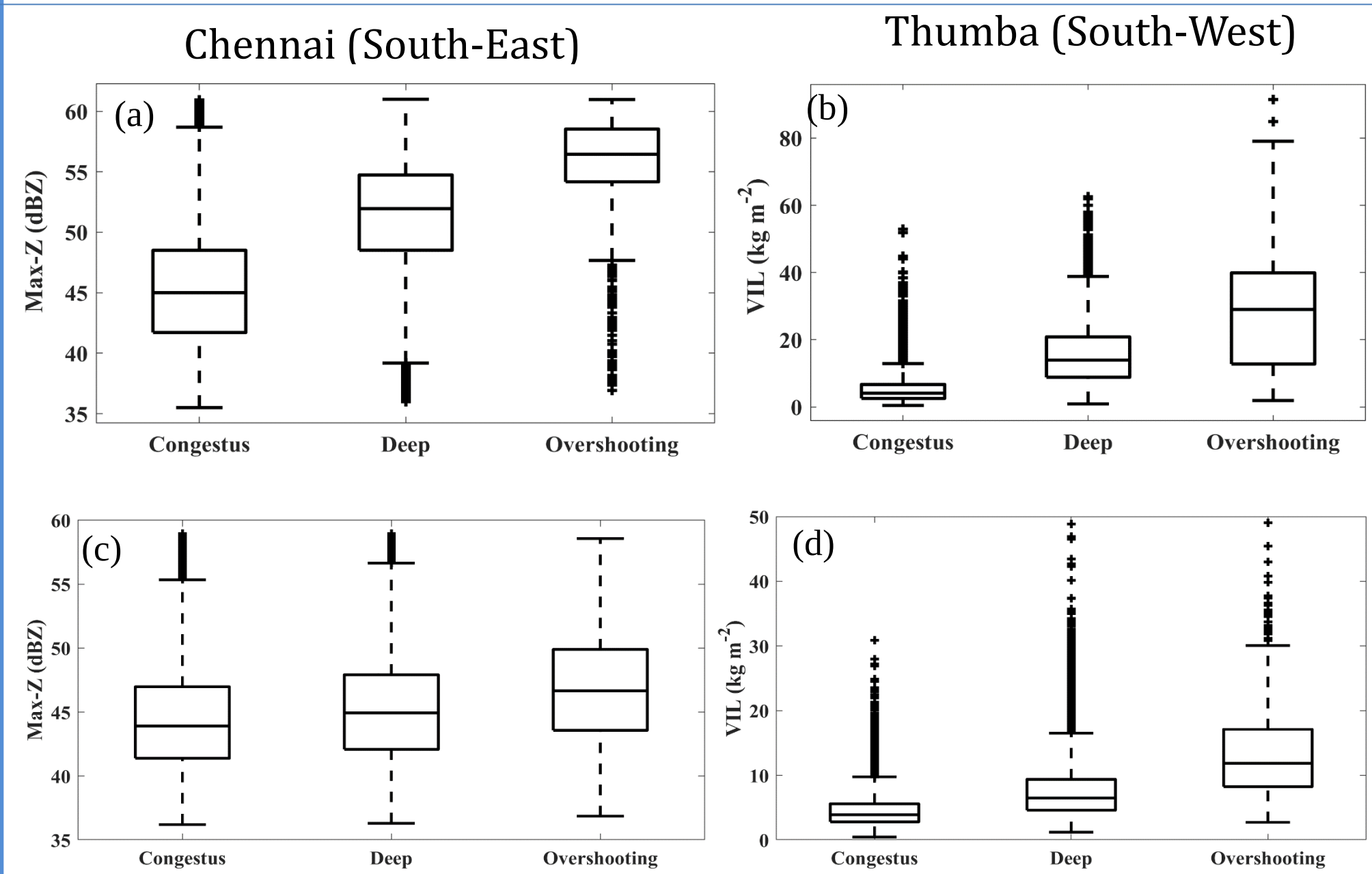


Fig 4 Box plot of (a) Max-Z and (b) VIL over Chennai, (c) and (d) are same as (a) and (b) over Thumba

- ❖ Convective Storms (CS) with top between 3 and 7 km are classified as congestus, between 7 and 15 km are classified as deep, and greater than 15 km are classified as overshooting CS.

- ❖ Congestus- South-West ----- 60 % South-East ----- 77%
- ❖ Deep - South-West ----- 39% South-East ----- 18 %
- ❖ Overshooting- South-West ----- 1% South-East ----- 1.5%

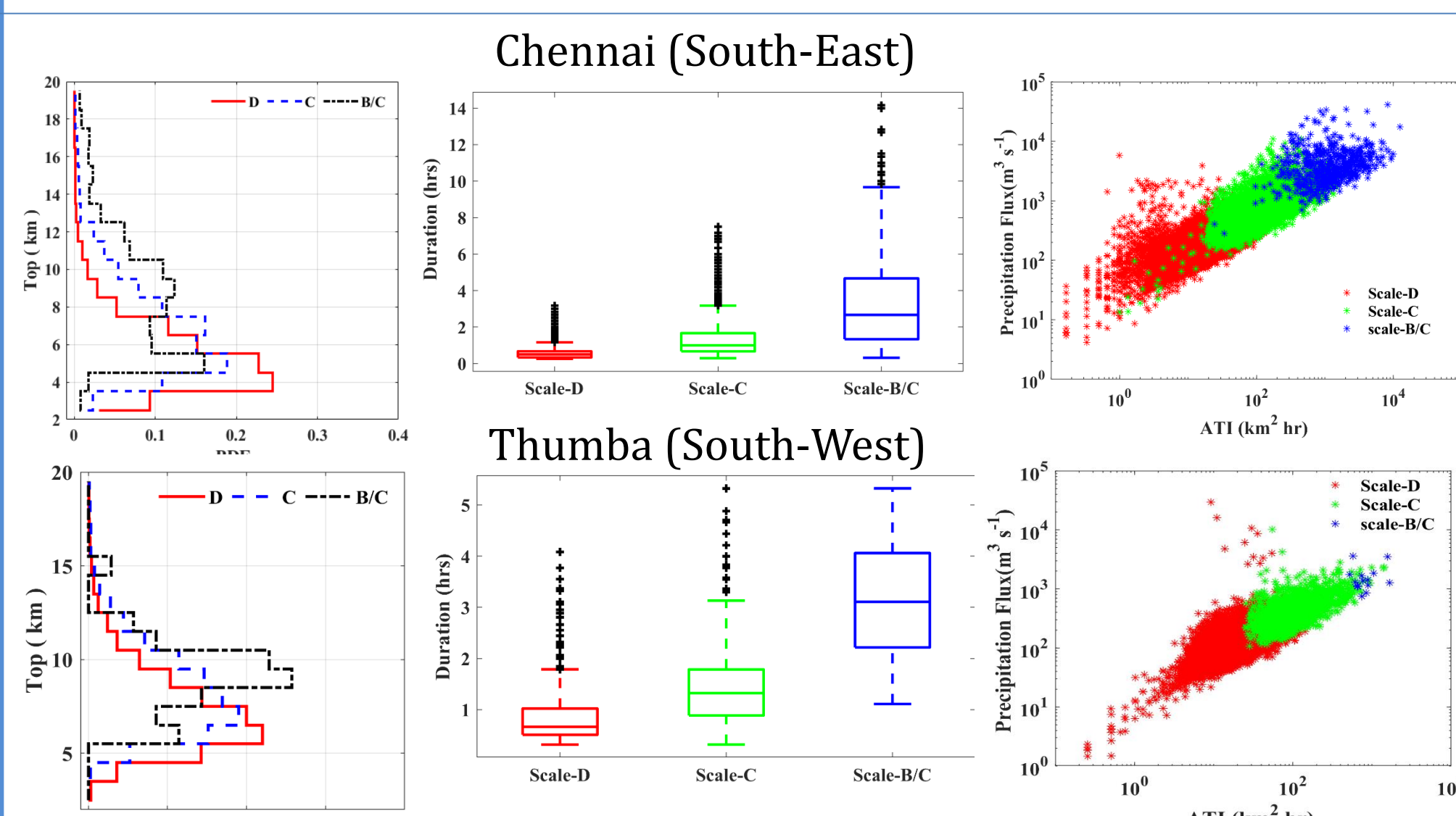


Fig 5 (a) PDF of 35 dBZ storm top, (b) Box-whisker plots of Duration, (c) Scatter plot of precipitation flux and Area Time Integral (ATI) for D, C, and B/C scale convective storms.

- ❖ D-Scale - South-West ----- 85% South-East ----- 75%
- ❖ C-Scale - South-West ----- 14% South-East ----- 23%
- ❖ B/C- Scale - South-West ----- 1% South-East ----- 2%

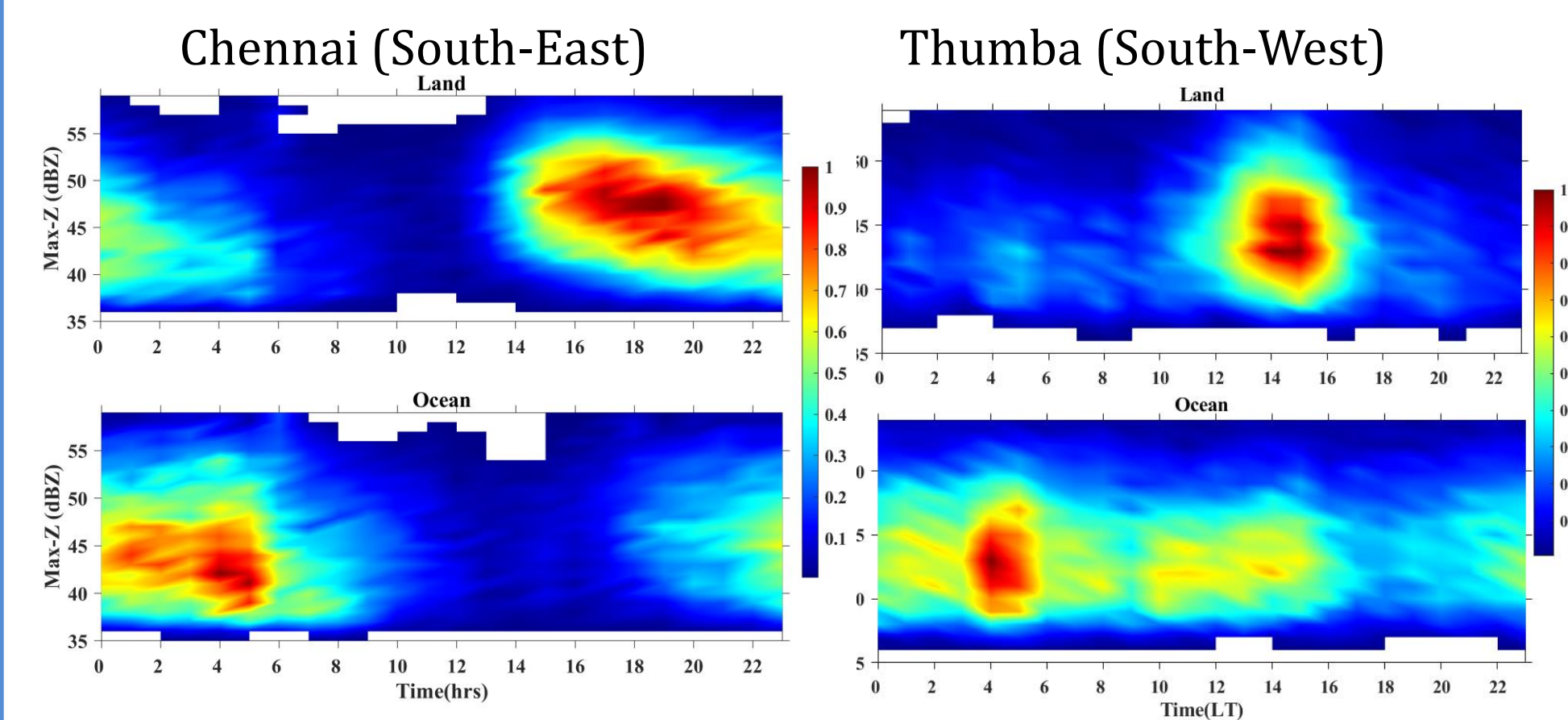


Fig 6 Diurnal variation of normalised occurrence of Max-z over land and ocean, respectively.

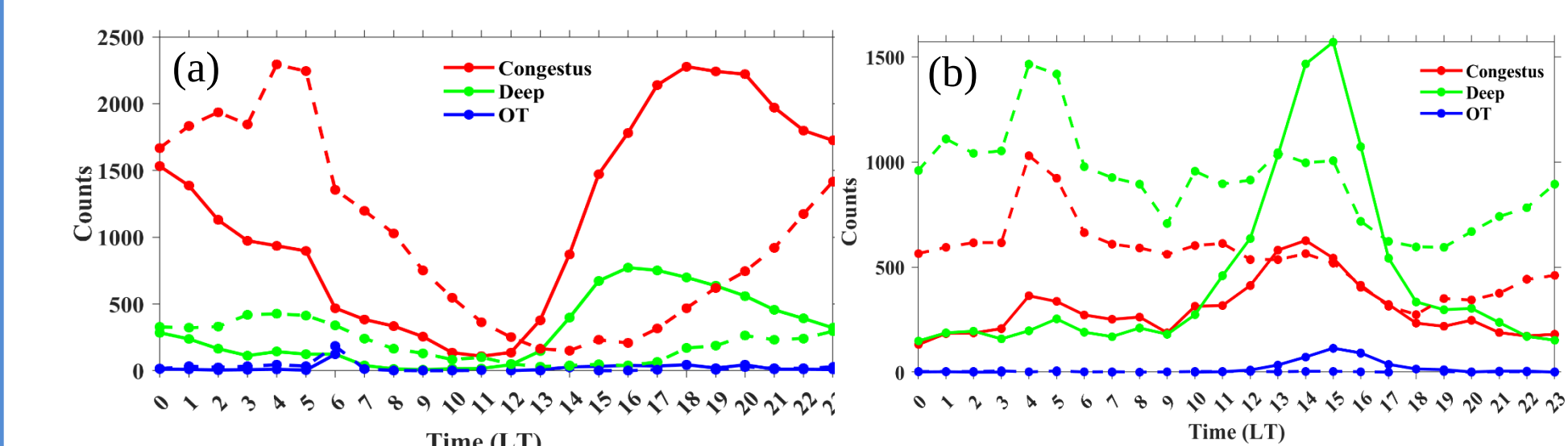


Fig 7 Diurnal variation of occurrence of (a) congestus (solid line), and (b) deep (dashed line) over (a) Land and (b) Ocean,

- ❖ The occurrence of storms over south-east peaks between 17 and 18 LT over the land and between 00-04 LT over the ocean.
- ❖ The occurrence of storms over south-west peaks between 14 and 15 LT over the land and between 04-05 LT, 14-15 LT, and a small peak at 22 LT over the ocean.
- ❖ The dominant peak in the afternoon over the land is caused by the deep CS over the south-west, however congestus over the south-east

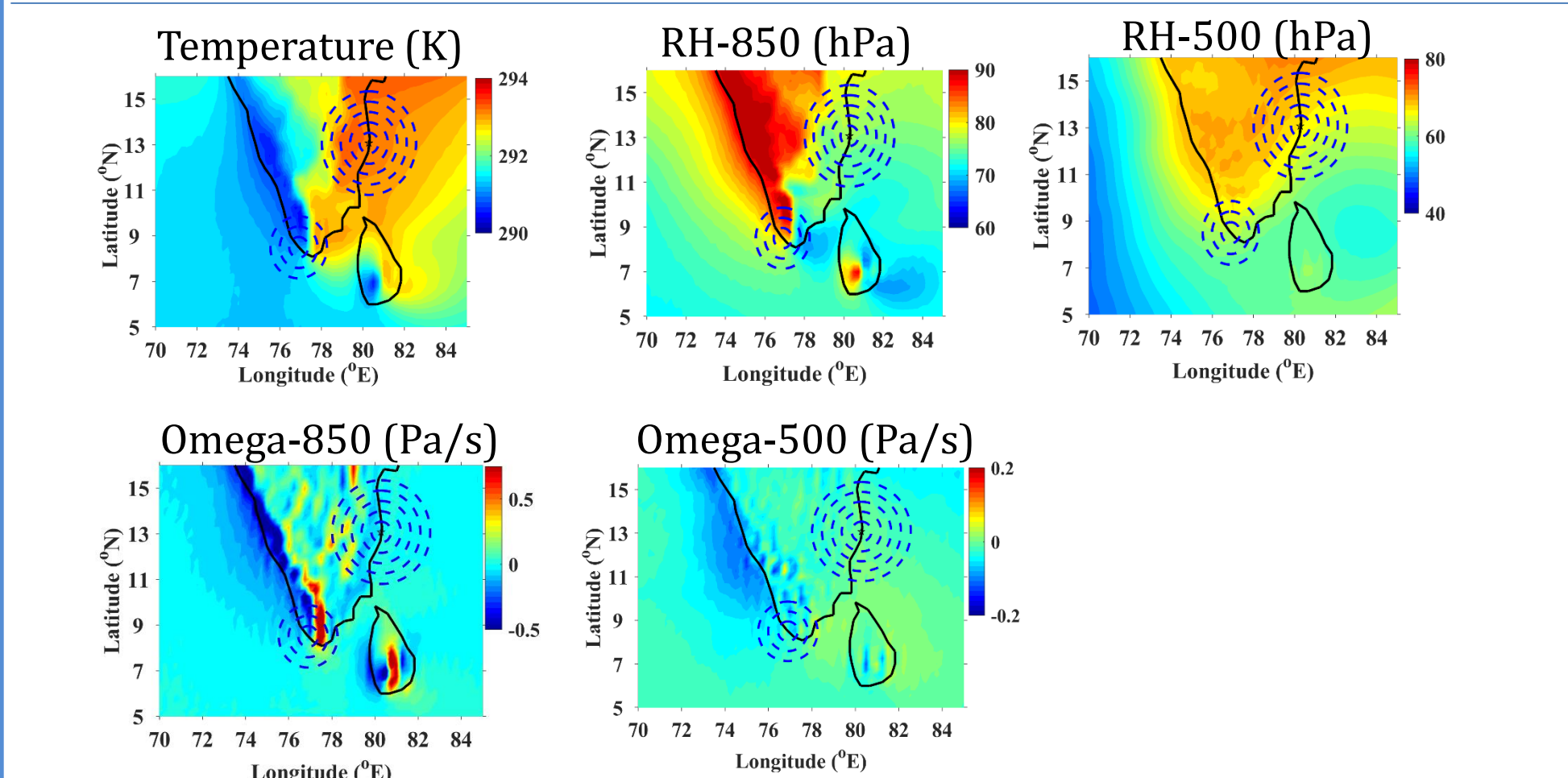


Fig 8 Spatial map of Temperature, RH at 850 and 500 hPa, Omega at 850 and 500 hPa

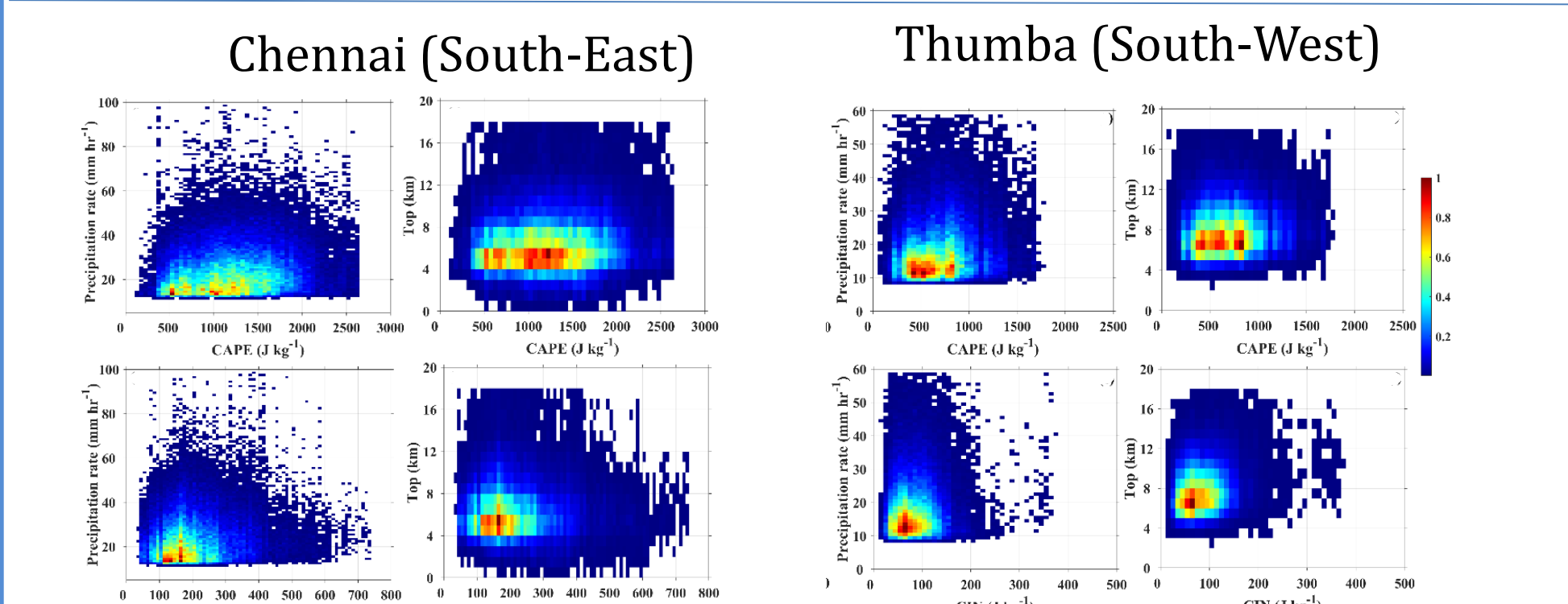


Fig 9 2D correlation of CAPE and CIN with precipitation rate and storm top over south-west and south east.

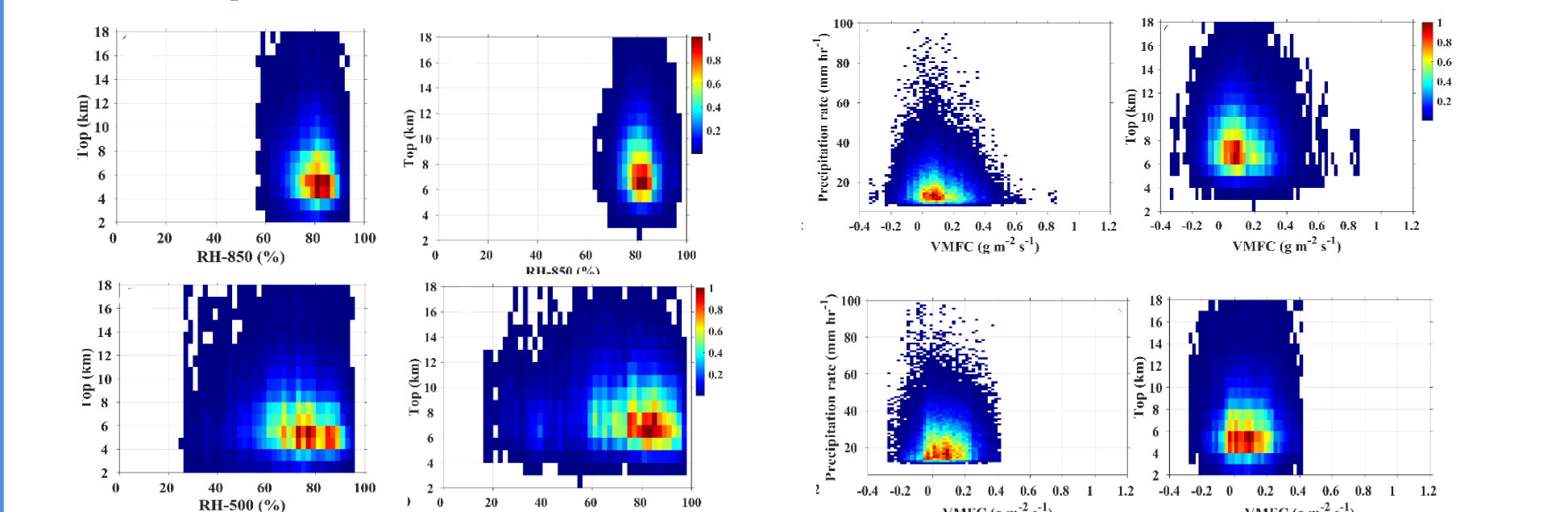


Fig 10 2D correlation of RH at 850 and 500 hpa and VMFC over south-west and south east.

Conclusions

- ✓ The convective storm over the gateway and the rain shadow regions are examined using DWR at Thumba and Chennai.
- ✓ The convective storms are intense (Max-Z) over the rain-shadow compared to the gateway. The storm tops are high over the gateway compared to rain-shadow. Most of the convective storms are observed below 5 km over the rain-shadow region, however the duration of the storms are higher.
- ✓ Congestus are more dominant over the rain-shadow with less occurrence of deep.D-scale storms are more over gateway, whereas C-scale are more over the rain-shadow region.
- ✓ Diurnal variability over the gateway showed a distinct afternoon peak over the land, and a trimodal peak over ocean.
- ✓ Diurnal variability over the rain-shadow shows an evening peak over the land and early morning peak over ocean.
- ✓ High humidity, guided by moisture convergence is crucial for the gateway, however strong stability and moisture transport over the rain-shadow region.

References

1. Houze Jr, R. A. (2004). Mesoscale convective systems. *Reviews of Geophysics*, 42(4).
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3. Dixon M, and Wiener G (1993) TITAN: Thunderstorm identification, tracking, analysis, and nowcasting—A radar-based methodology. *Journal of Atmospheric and Oceanic Technology*, 10(6), 785–797. [https://doi.org/10.1175/1520-0426\(1993\)010<0785:TITAN>2.0.CO;2](https://doi.org/10.1175/1520-0426(1993)010<0785:TITAN>2.0.CO;2)