

Understanding land-ocean contrast in lightning strikes across Australia

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Motivation

Why is lightning more frequent over land than over the ocean — particularly in the tropical regions of Australia?

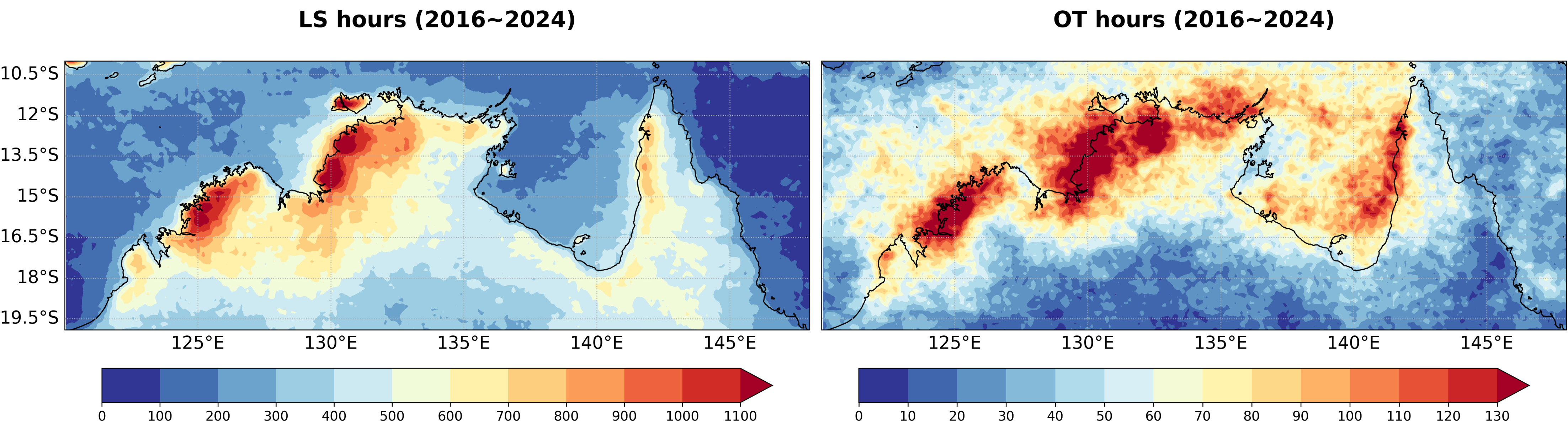


Fig 1 : Lightning Strikes hours and Overshooting Tops for period 2016 – 2024.

- Lightning activity is mainly concentrated over land, while overshooting tops occur over both land and ocean. (fig1)
- Over land, activity peaks in the late afternoon. Over the ocean, it peaks in the early morning. (fig 2)

On exploring the convective parameters at these locations, we classified the cases into three groups: OT only (no LS), OT with LS > 1, and LS only (no OT), further divided into land and ocean.

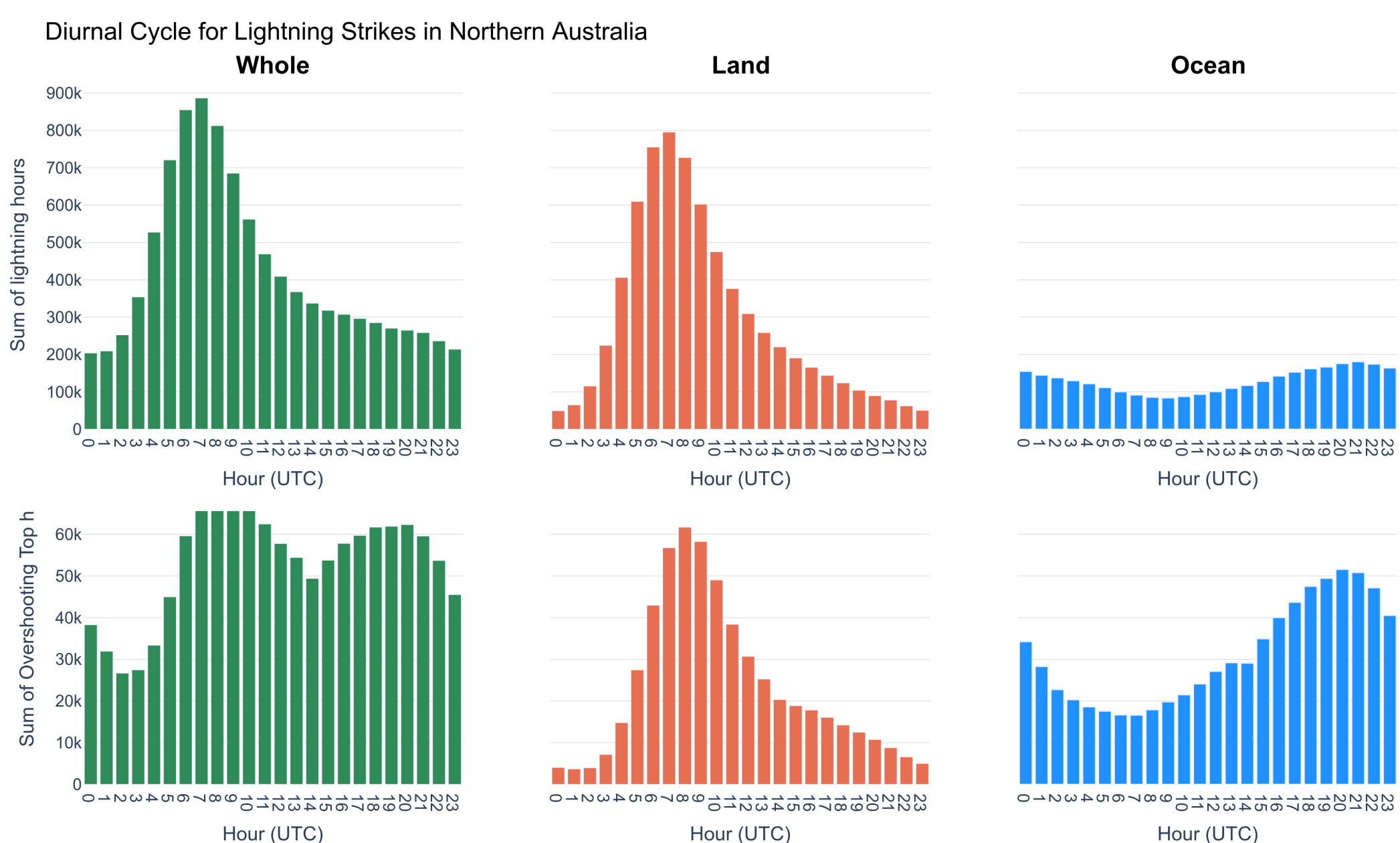


Fig. 2: Diurnal cycle of LS and OT hours over land and ocean.

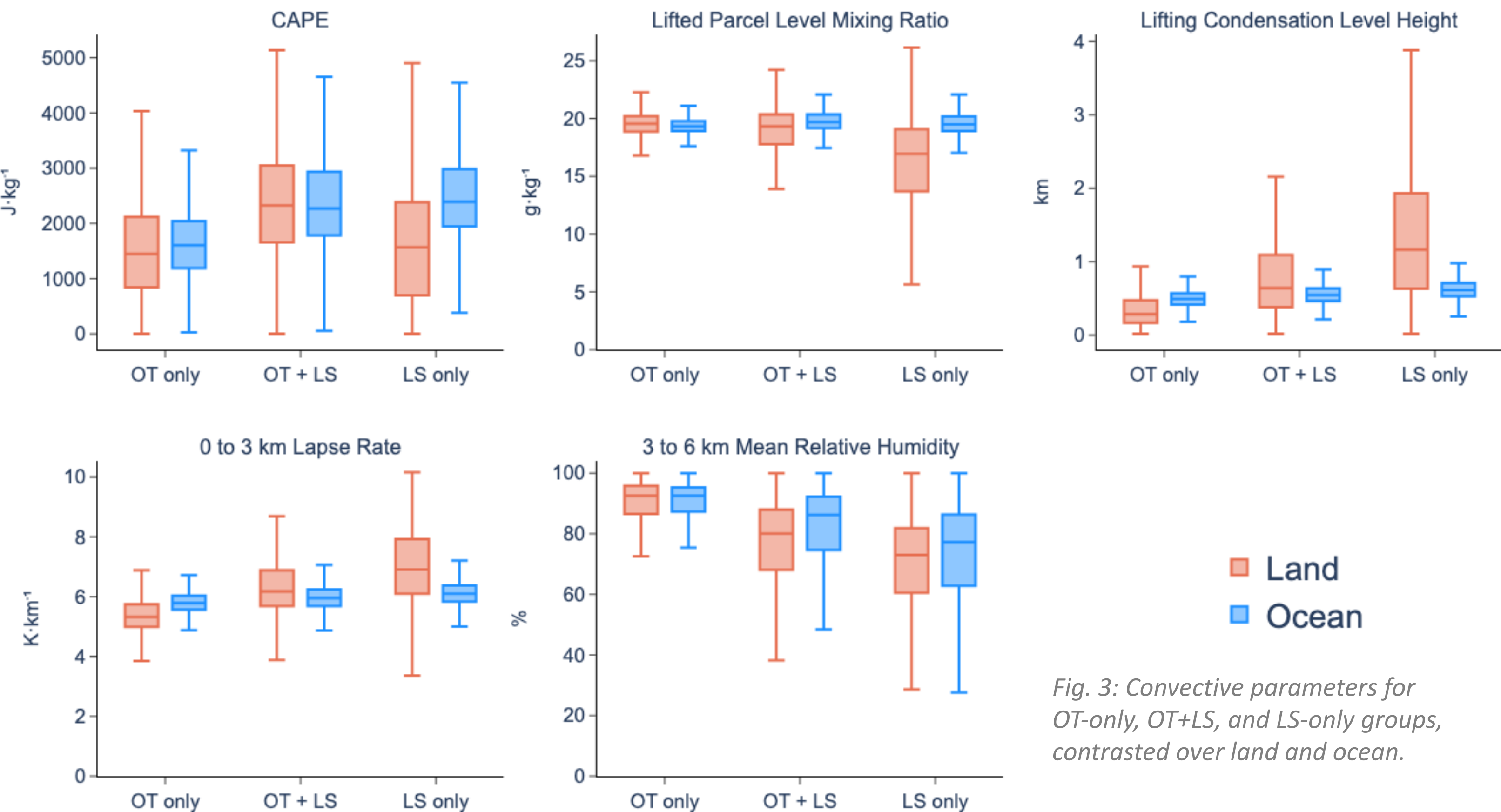


Fig. 3: Convective parameters for OT-only, OT+LS, and LS-only groups, contrasted over land and ocean.

- On the density plot for land we observe two clusters: one with **steeper lapse rates, higher Lifting condensation level and lower CAPE**, and another overlapping with the **ocean cluster**, showing **high CAPE, moderate Lifting condensation level and Moderate surface-based lapse rates**. (fig 5)

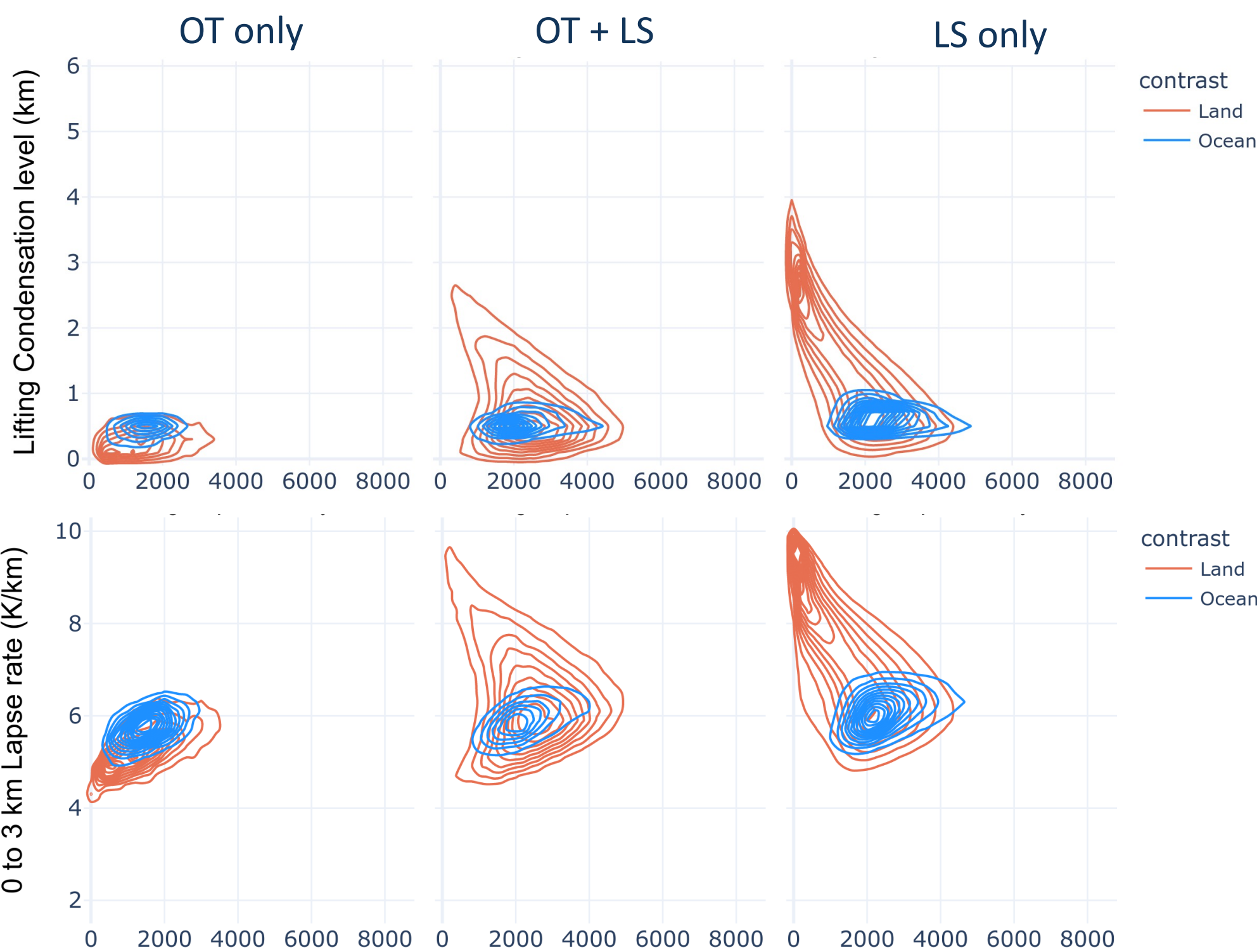


Fig. 5: Density plot showing the relationship between LCL, surface-based lapse rate and CAPE.

Acknowledgements

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References

Khlopenkov, K. V., K. M. Bedka, J. W. Cooney, and K. Itterly, 2021: Recent Advances in Detection of Overshooting Cloud Tops from Longwave Infrared Satellite Imagery. *Journal of Geophysical Research: Atmospheres*, 126, e2020JD034359. <https://doi.org/10.1029/2020JD034359>
Williams, E., & Stanfill, S. (2002). The physical origin of the land–ocean contrast in lightning activity. *Comptes Rendus Physique*, 3(10), 1277–1292

Data

Lightning Strikes (LS) : Ground-based lightning observations from the Weatherzone Total Lightning Network.

Overshooting Top (OT) : OT events are detected based on infrared satellite imagery using the method of Khlopenkov et. al. (2021).[NASA Langley Research Center]

Convective Parameters : BARRA – R2, 0-3 km lapse rate (LR03, K km⁻¹), 3 to 6 km Mean relative humidity (%), Lifting condensation level height (LCL, km), Lifted parcel mixing ratio (LPL, g.Kg⁻¹) and Convective available potential energy of most-unstable parcel (CAPE, J kg⁻¹) between the surface and 500 hPa or the -20 °C level (whichever is lower).

Time period : 2016 – 2024 year
Spatial resolution : ~ 12 km
Area of Interest : 10°S–20°S, 120°E–148°E.

- Lightning over land can occur in range of environment (LR03, LPL and LCL) whereas over ocean they are consistent. (fig 3 & fig 4)
- For LS-only events, CAPE over land is lower than over the ocean, while Convective Inhibition is highest over land. (fig 3 & fig 4)
- Higher LCL over land suggests the generation of broader thermals, leading to wider updrafts that are less prone to entrainment, as hypothesized by Williams et al. (2002) (fig 3 & fig 4)
- The high mid-level relative humidity appears to support deep convection in the OT-only group (Lower Instability than LS only), reducing dilution, and serves as a clear indicator for distinguishing the groups. (fig 3 & fig 4) [Interpretation]

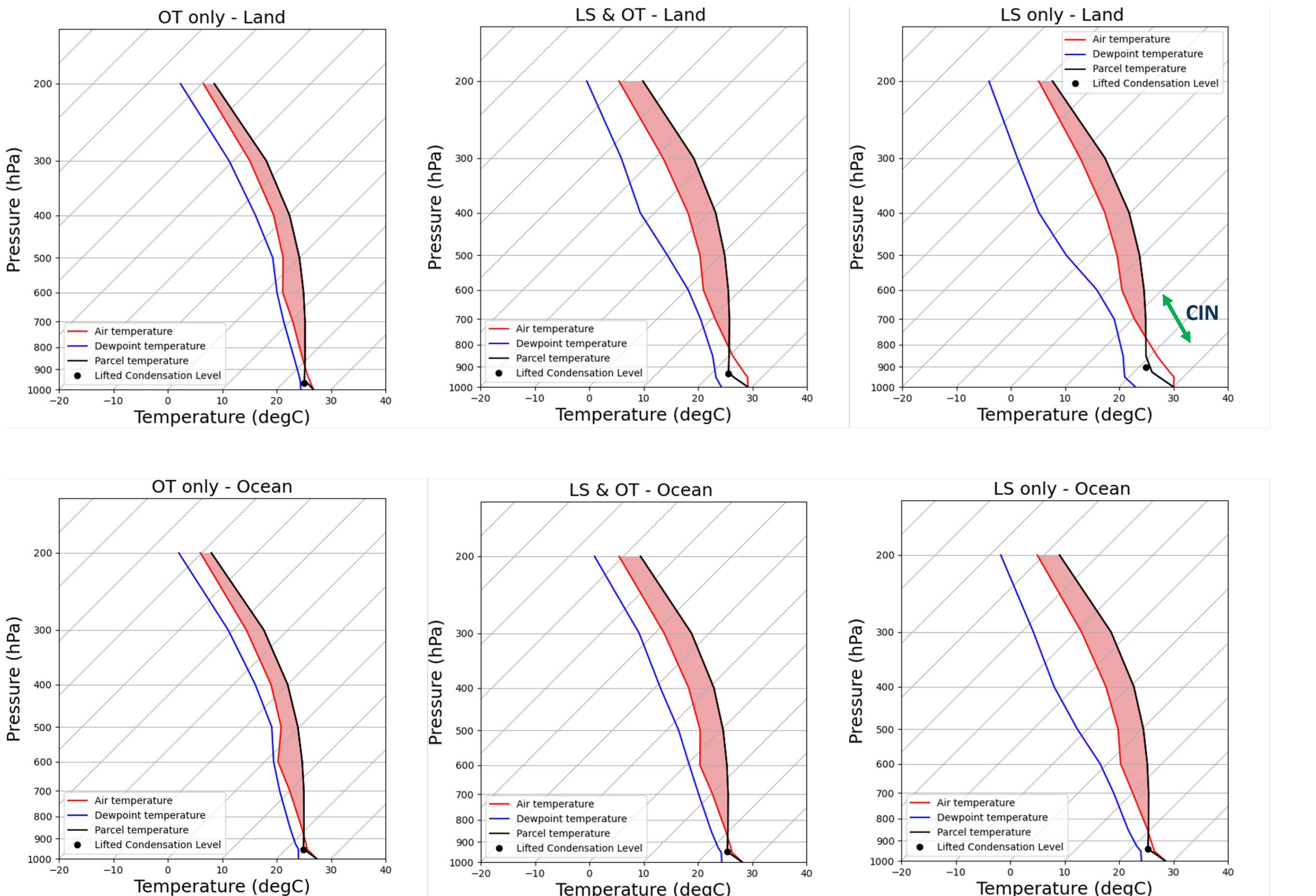


Fig 4 : Average skew T-log P plot for period 2016 ~ 2024.