

2025年竹節草颱風及西南氣流 豪雨事件之大氣觀測資料分析

Analyses of atmospheric observations of torrential rainfall of
Typhoon Co-May and southwest monsoon flow in 2025

陳燕玲 陳台琦 齊祿祥

Chen Y.-L., Chen T.-C., Chi L.-H.

中央氣象署 大氣觀測組

Central Weather Administration Observation Division

CWAO



Y.L.Chen



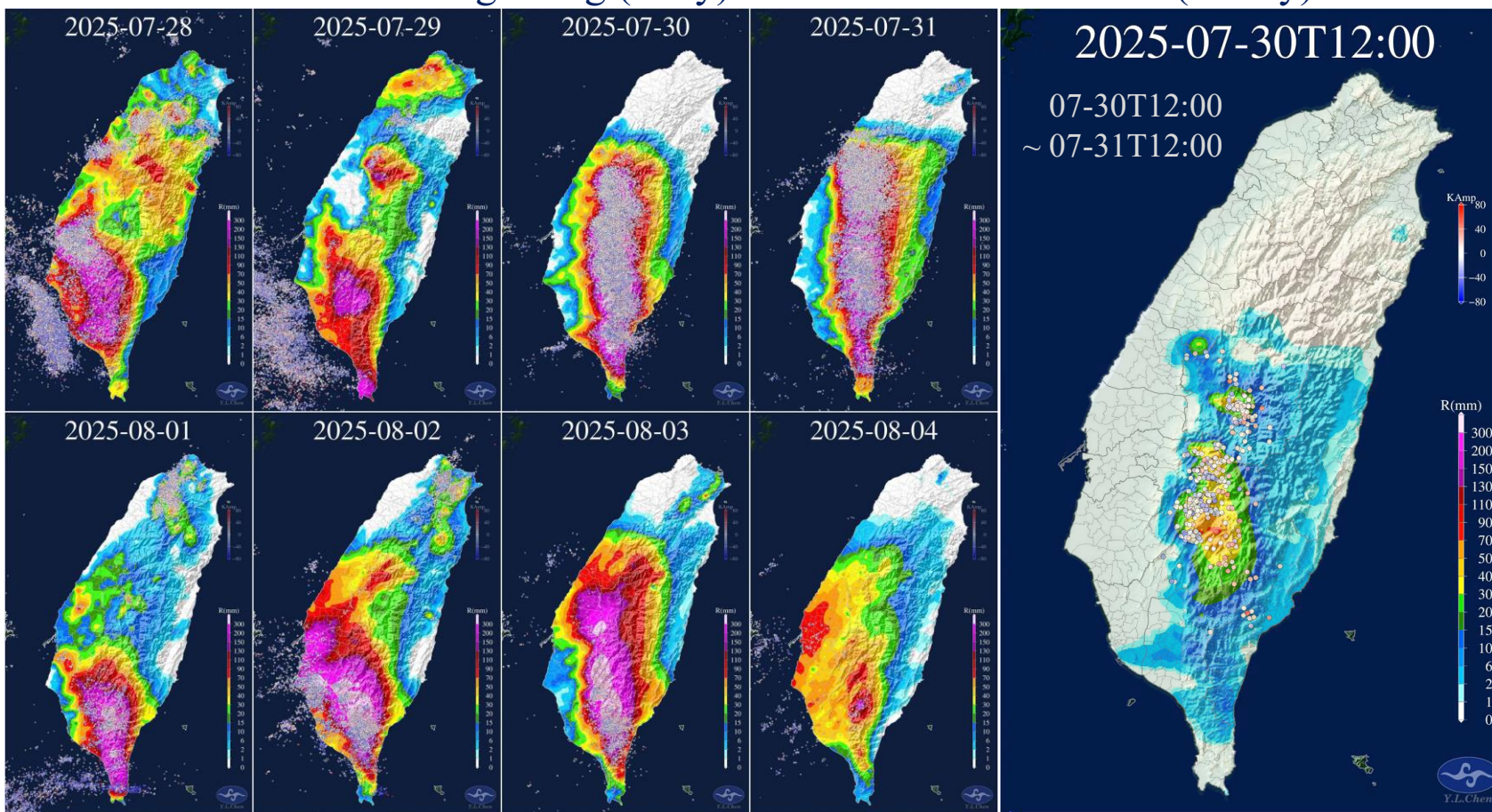
Motivation and objectives

2025-07-28 ~ 08-04竹節草颱風及西南氣流豪雨事件

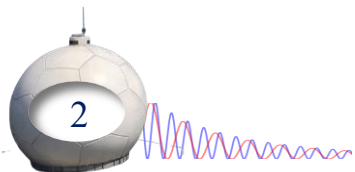
Torrential Rainfall of Typhoon CO-MAY and Southwest Monsoon Flow in 2025

rainfall and lightning (daily)

(hourly)



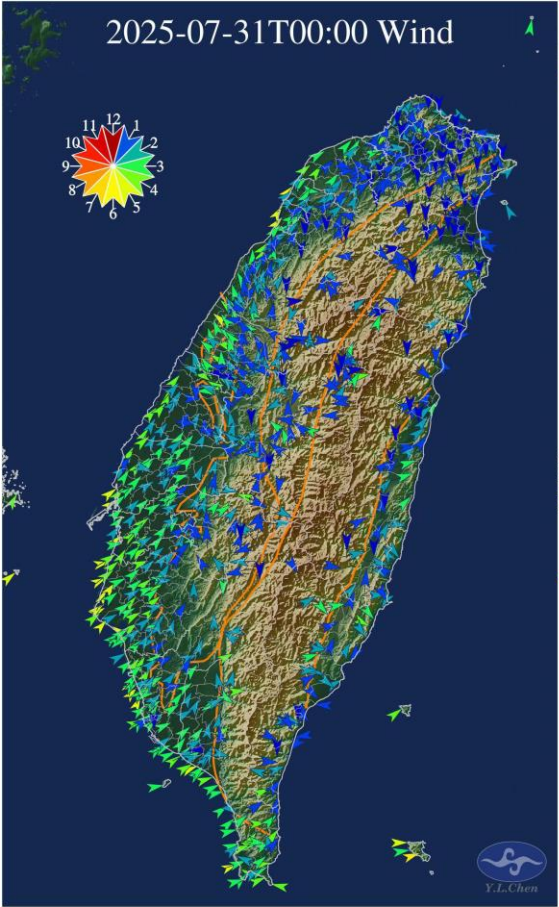
- The relationship between lightning activity and rainfall in thunderstorms.
- Lightning highly correlated to severe rainfall region.



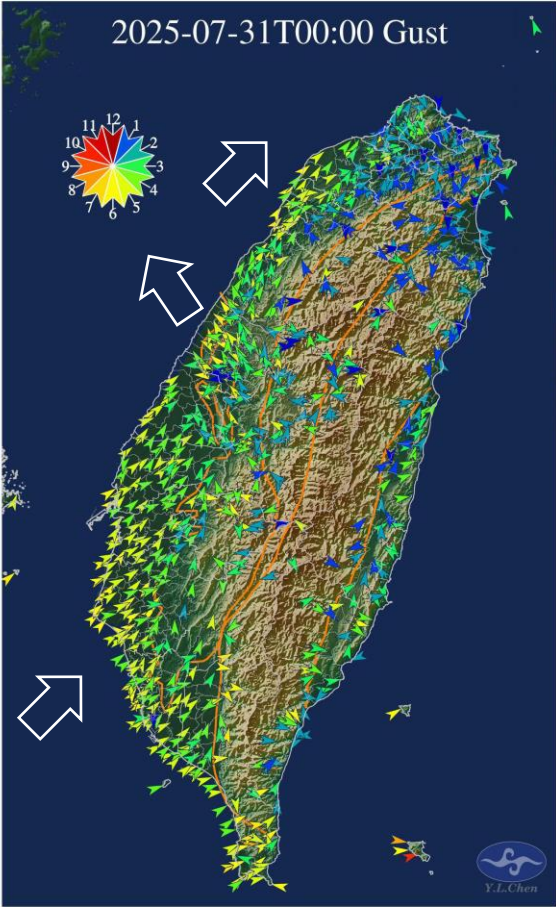


The topographic effect 地形效應

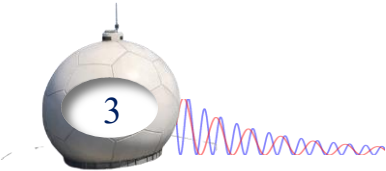
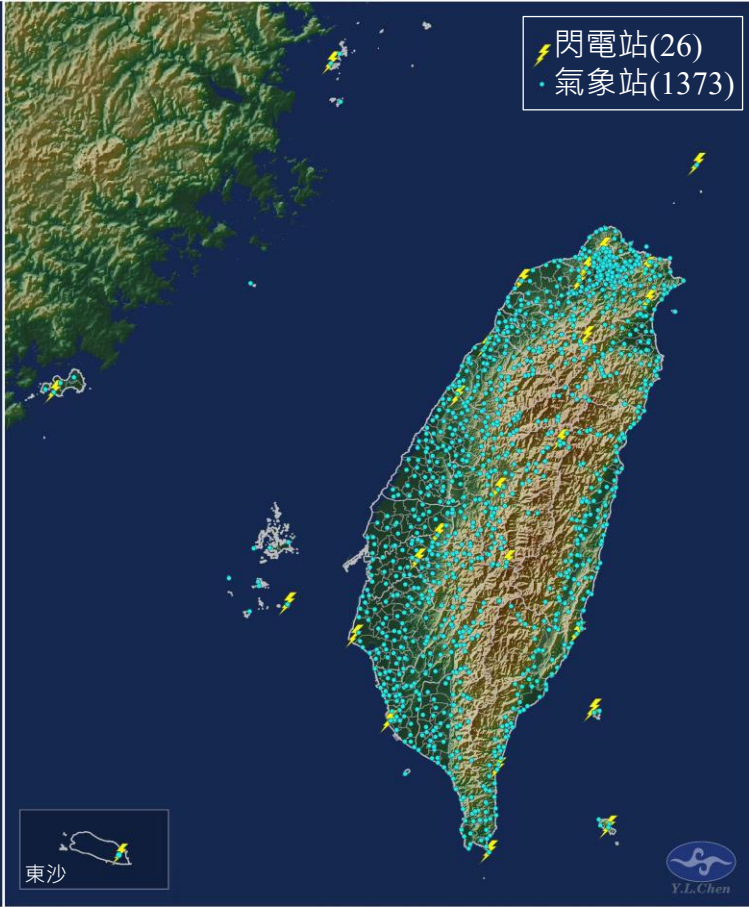
平均風(級)



陣風(級)

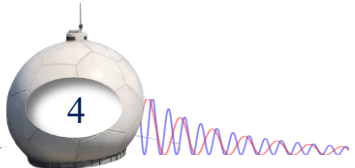
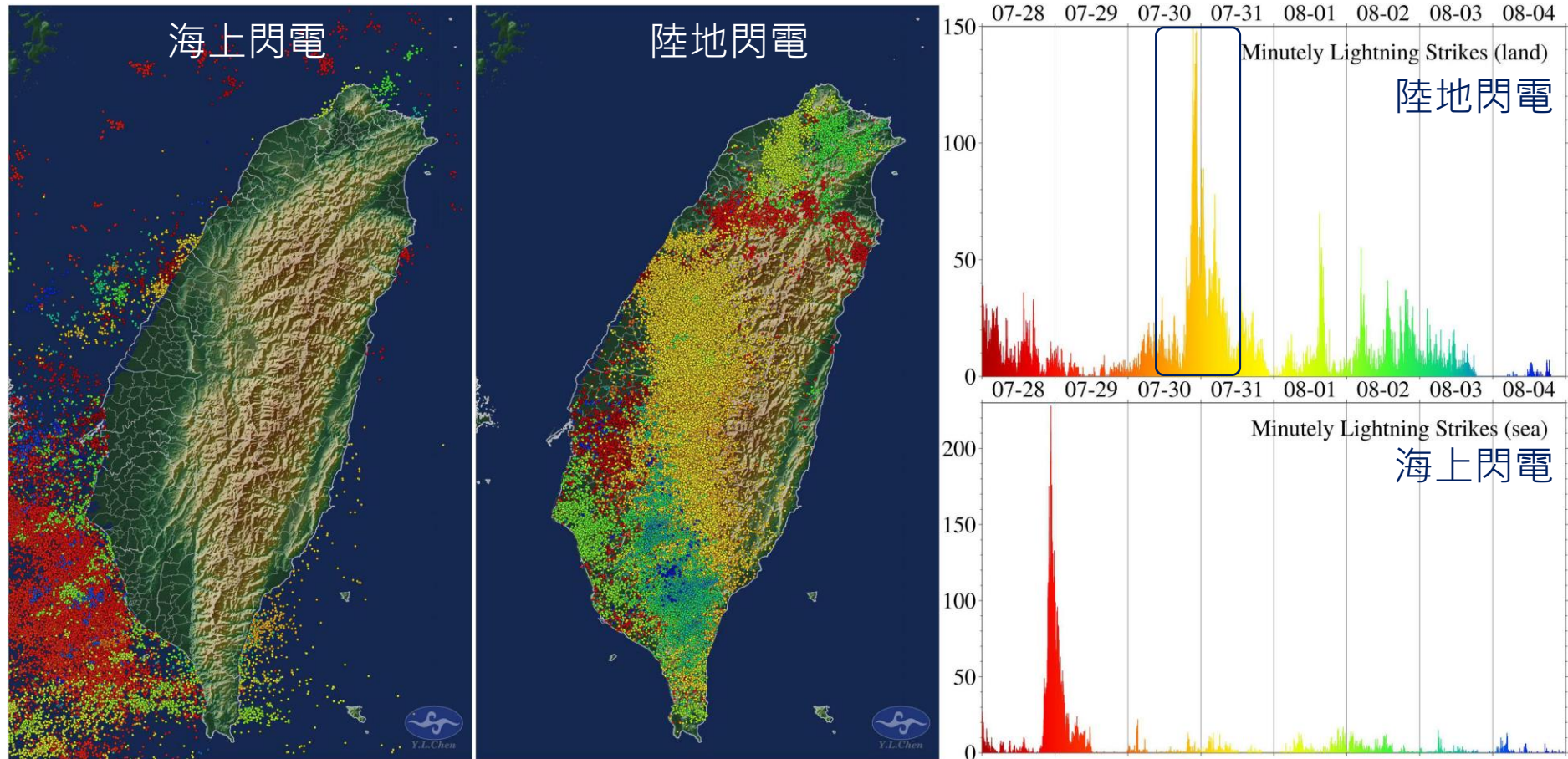


閃電站及氣象站





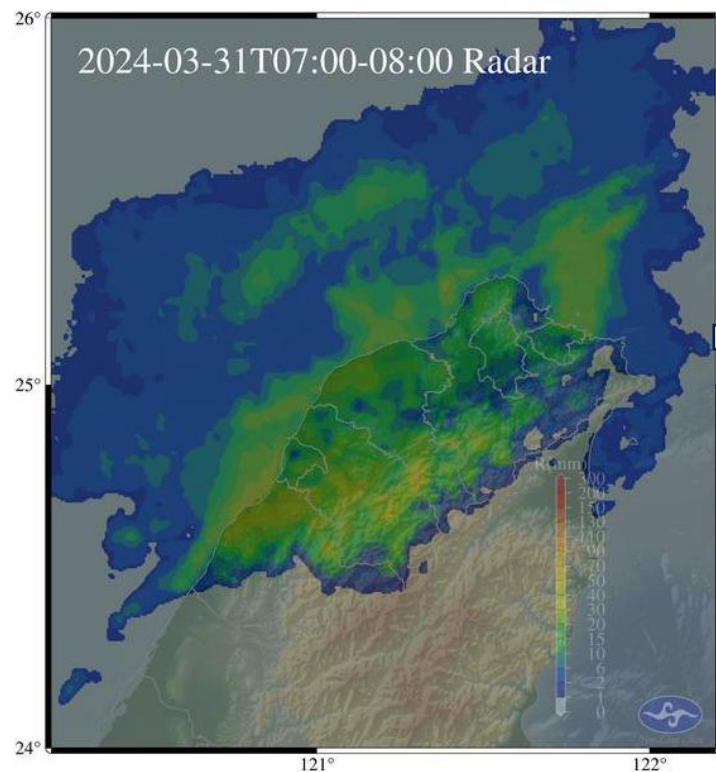
Lightning time series distribution



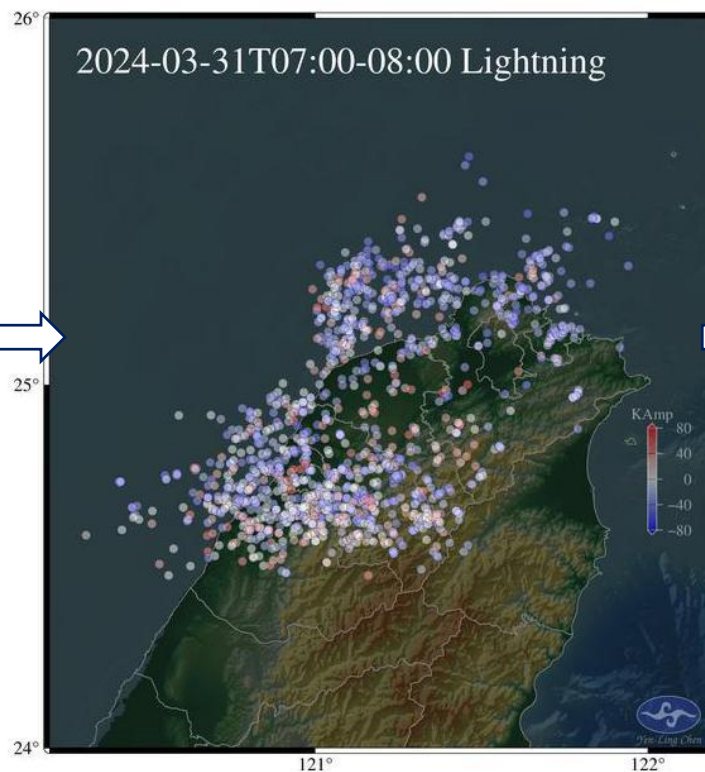


雷達回波-閃電-降雨(2024-03-31T07:00-08:00)

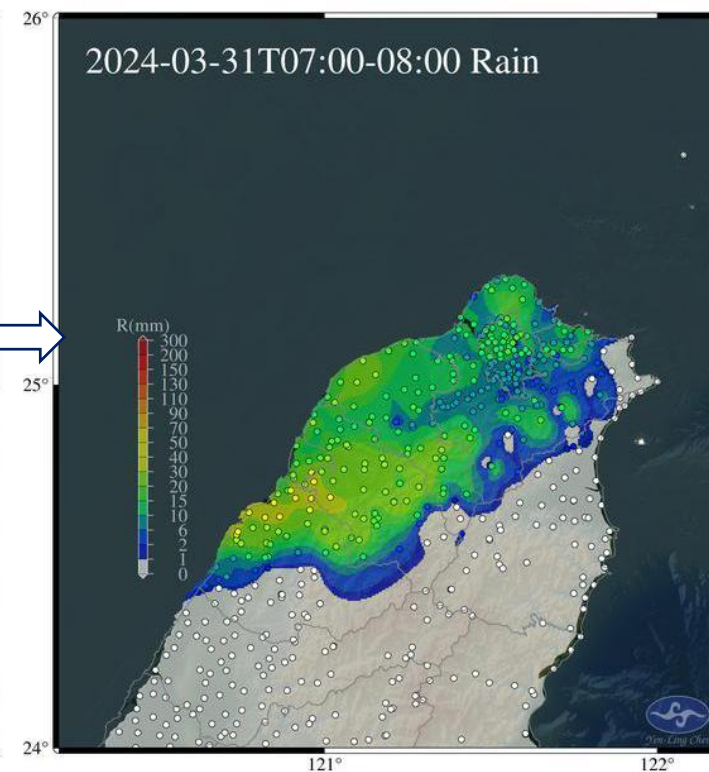
雷達回波



閃電



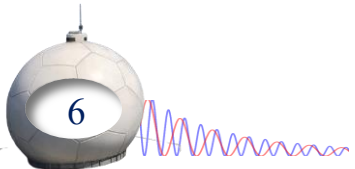
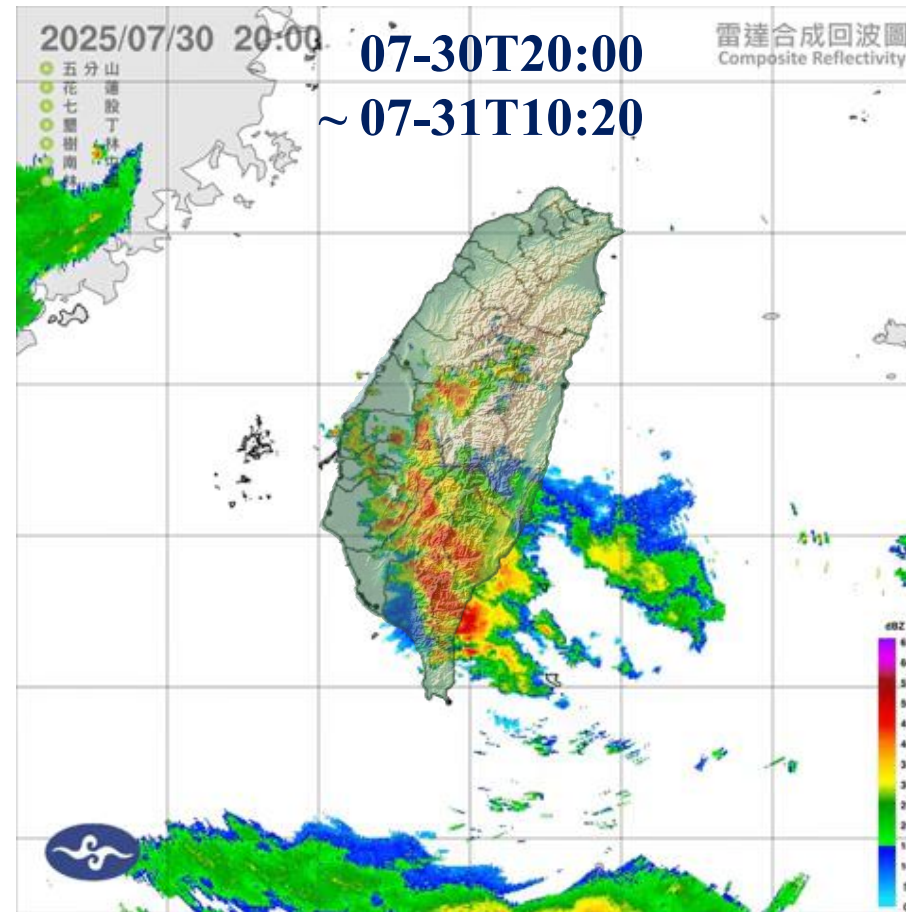
降雨(mm)



- 雷達回波、閃電、降雨之觀測具有明顯的時序關係與空間關聯。
- 閃電資料之應用: 雷達回波資料比對、定量降水估計、劇烈天氣監測。



Severe convection near the mountain





Literature Review

Cloud Microphysics and Polarimetric Radar Variables

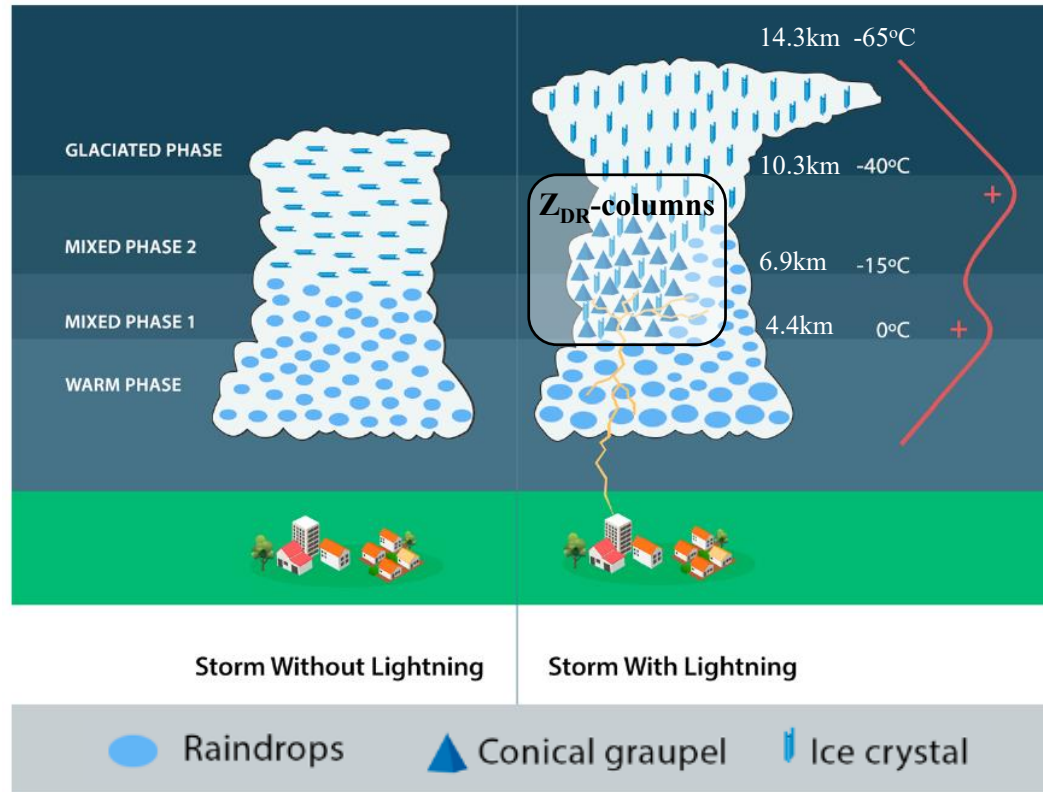
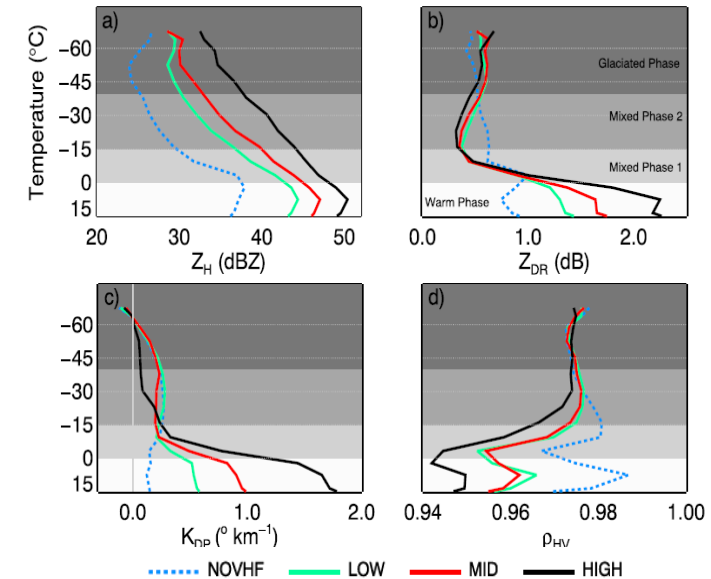


Figure 10. Schematic illustration of the main hydrometeor characteristics and VHF source count profile (red line) in storms with and without lightning activity.

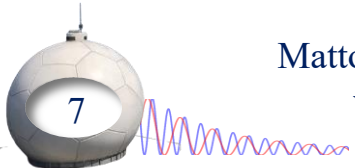
vertical alignment of ice crystal
strongly negative Z_{DR} , K_{DP}

strong updrafts and conical graupel
negative Z_{DR} , K_{DP} and moderate Z_H

supercooled freezing of raindrops
positive Z_{DR} , K_{DP} (Z_{DR} -columns)



Mattos, E. V., L. A. T. Machado, E. R. Williams, and R. I. Albrecht (2016), Polarimetric radar characteristics of storms with and without lightning activity, **J. Geophys. Res. Atmos.**, 121,14,201–14,220, doi:10.1002/2016JD025142.





Radar polarimetric variables (2025-07-30T21:00)

Z_H (dBZ)(mm⁶/m³)

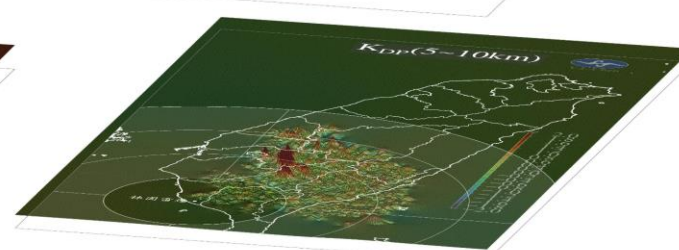
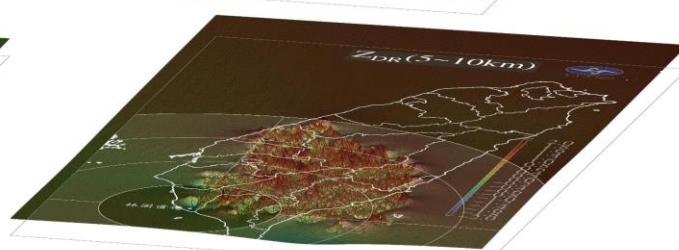
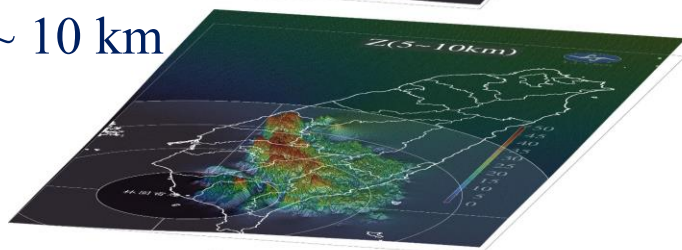
Z_{DR} (dB)

K_{DP} (deg/km)

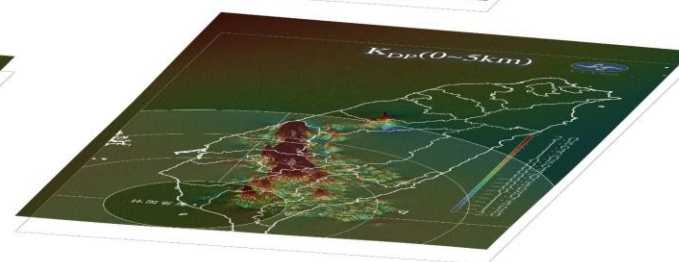
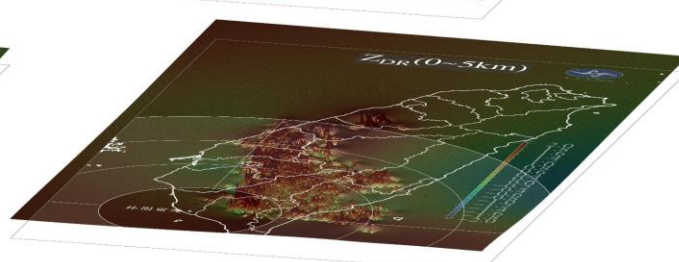
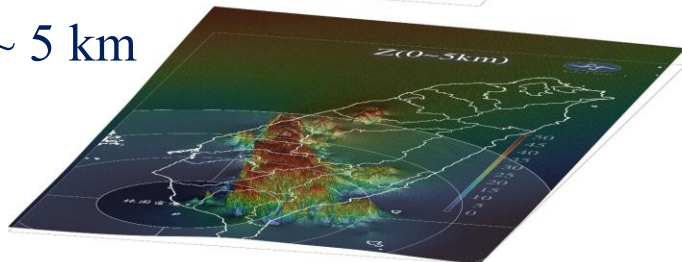
10 ~ 15 km



5 ~ 10 km



0 ~ 5 km



Polarimetric Radar Variables

Z_H (dBZ) : Horizontal Reflectivity

Z_{DR} (dB) : Differential Reflectivity

K_{DP} (deg/km): Specific Differential Phase



RCLY高雄林園雷達
PPI (Plan Position Indicator)



Literature Review

Lightning and Radar Reflectivity

The Relationship Between Lightning Activity and Ice Fluxes in Thunderstorms

Validation of the ice flux hypothesis using dual-polarimetric, dual-Doppler radar observations and total lightning data.

$$\text{Flux hypothesis } f = C \cdot p \cdot F_i = C \cdot (p_m \cdot v_t) \cdot (np_m \cdot w)$$

f: the **lightning rate**; **C**: constant; $p \cdot F_i$: the ice mass flux product

$p = (p_m \cdot v_t)$: the **downward** mass flux of solid **precipitation** (graupel)

p_m : precipitation ice mass

v_t : the terminal fall speed of hydrometeors

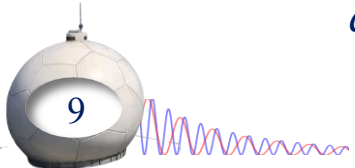
$F_i = (np_m \cdot w)$: the **upward** mass flux of ice crystals(**non-precipitation**)

np_m : non-precipitation ice mass

w : the vertical wind speed

p and F_i existing at the top of the charging zone

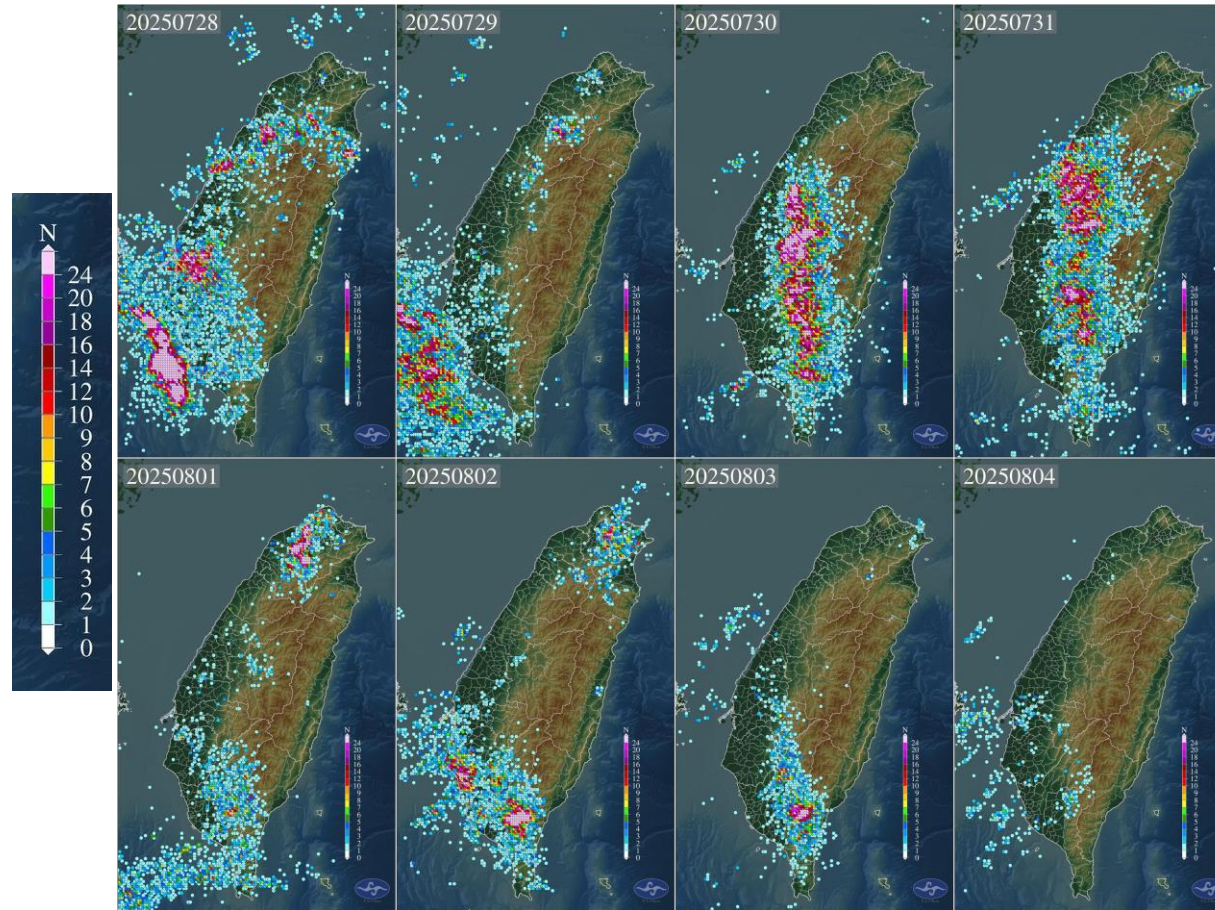
Deierling, W., W. A. Petersen, J. Latham, S. Ellis, and H. J. Christian (2008), The relationship between lightning activity and ice fluxes in thunderstorms, J. Geophys. Res., 113, D15210, doi:10.1029/2007JD009700.



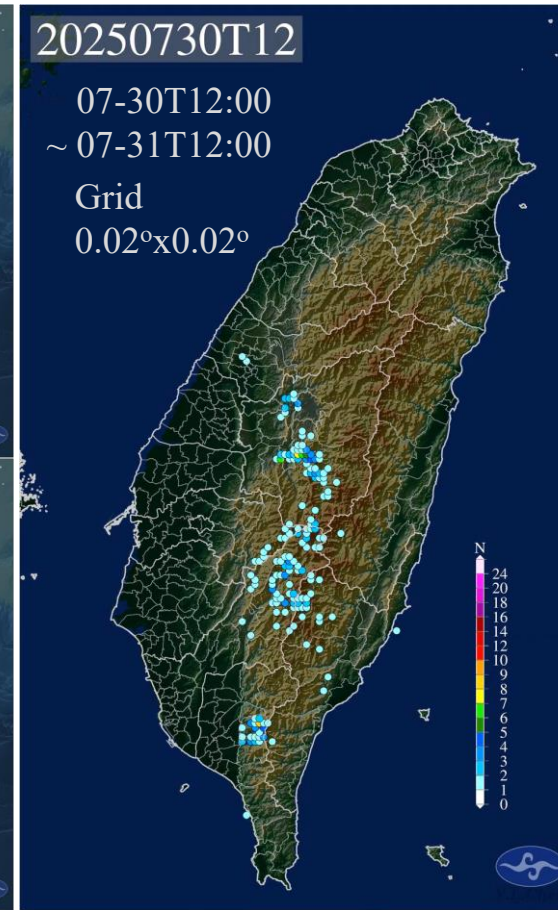


Lightning density

Lightning density (daily)



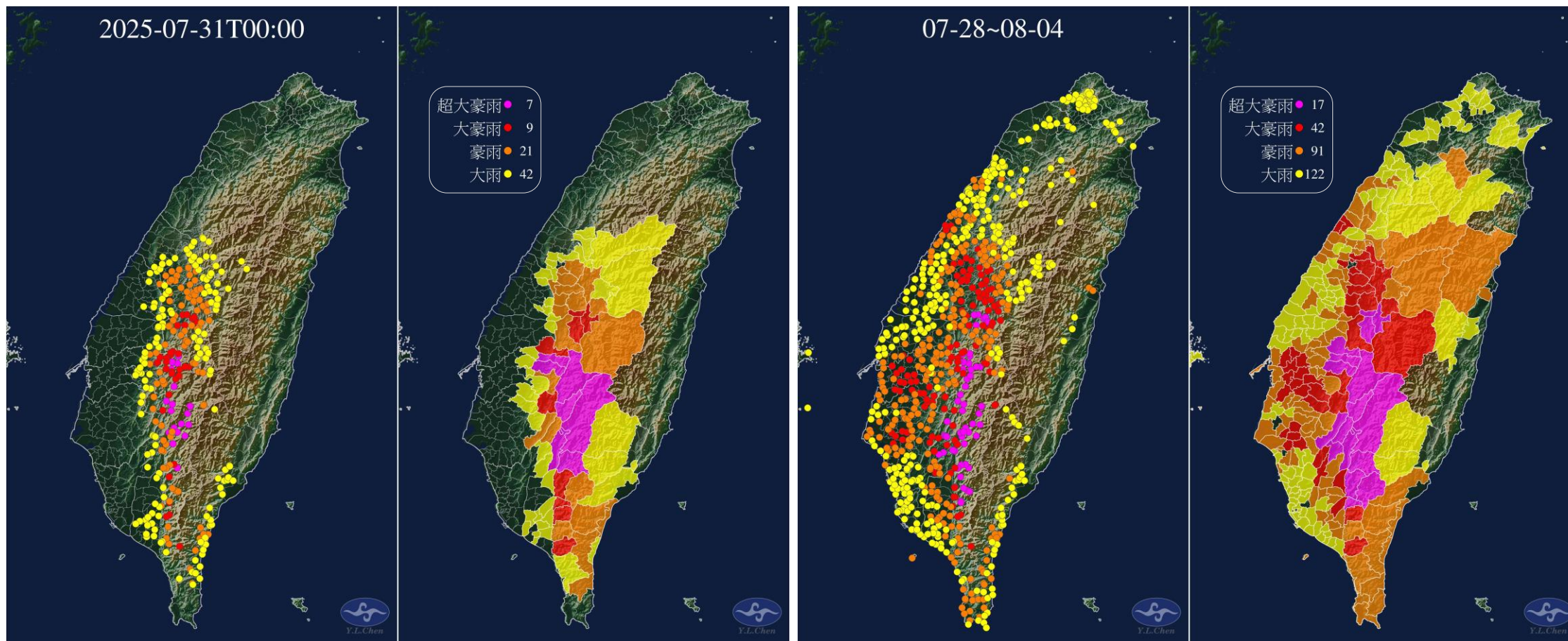
Lightning density (hourly)



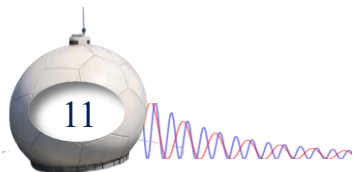
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- Lightning highly correlated to severe rainfall region.



Rainfall Classification 雨量分級

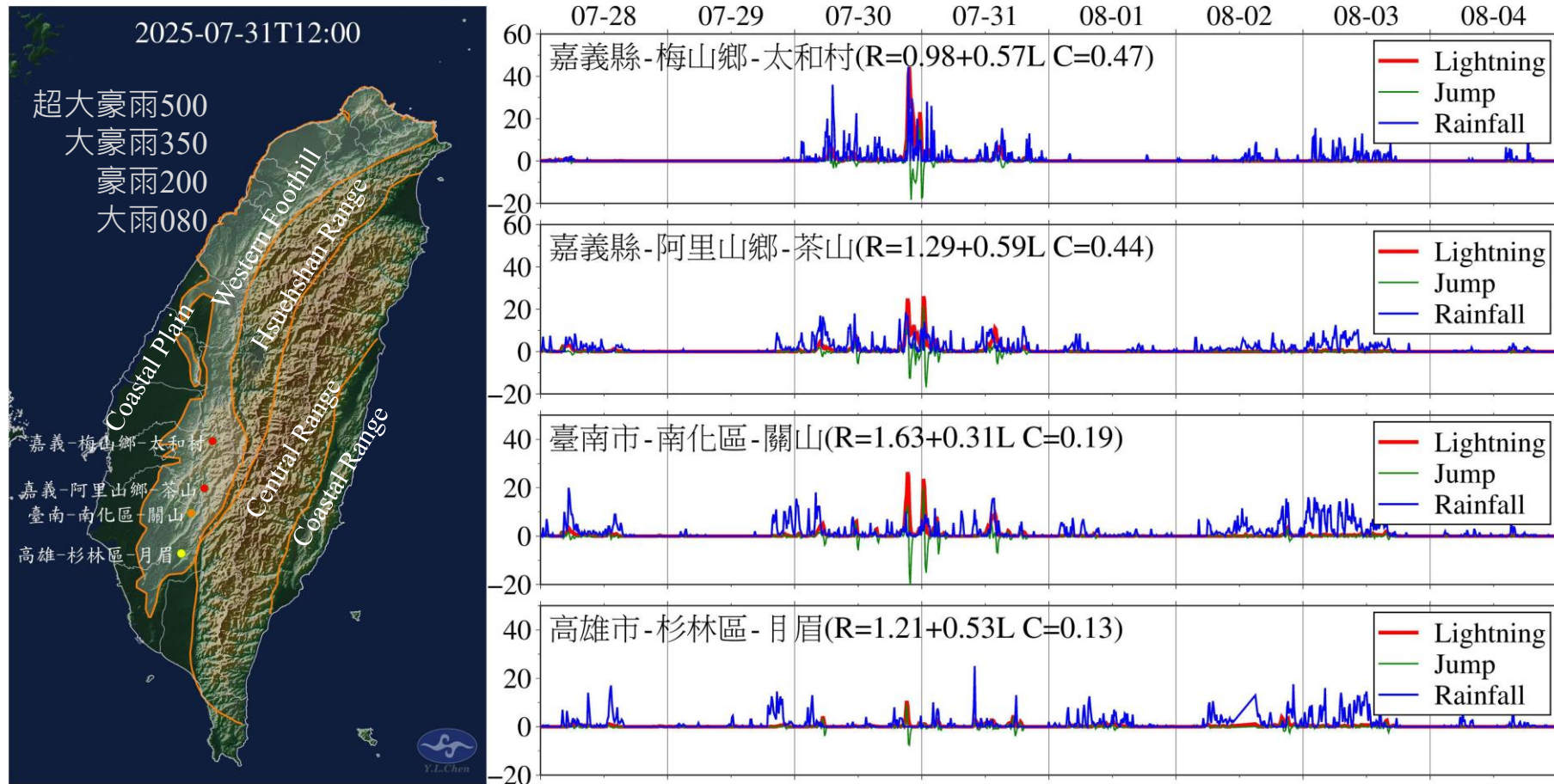


超大豪雨 500mm/24h
大豪雨 350mm/24h, 200mm/3h
豪雨 200mm/24h, 100mm/3h
大雨 80mm/24h, 40mm/1h





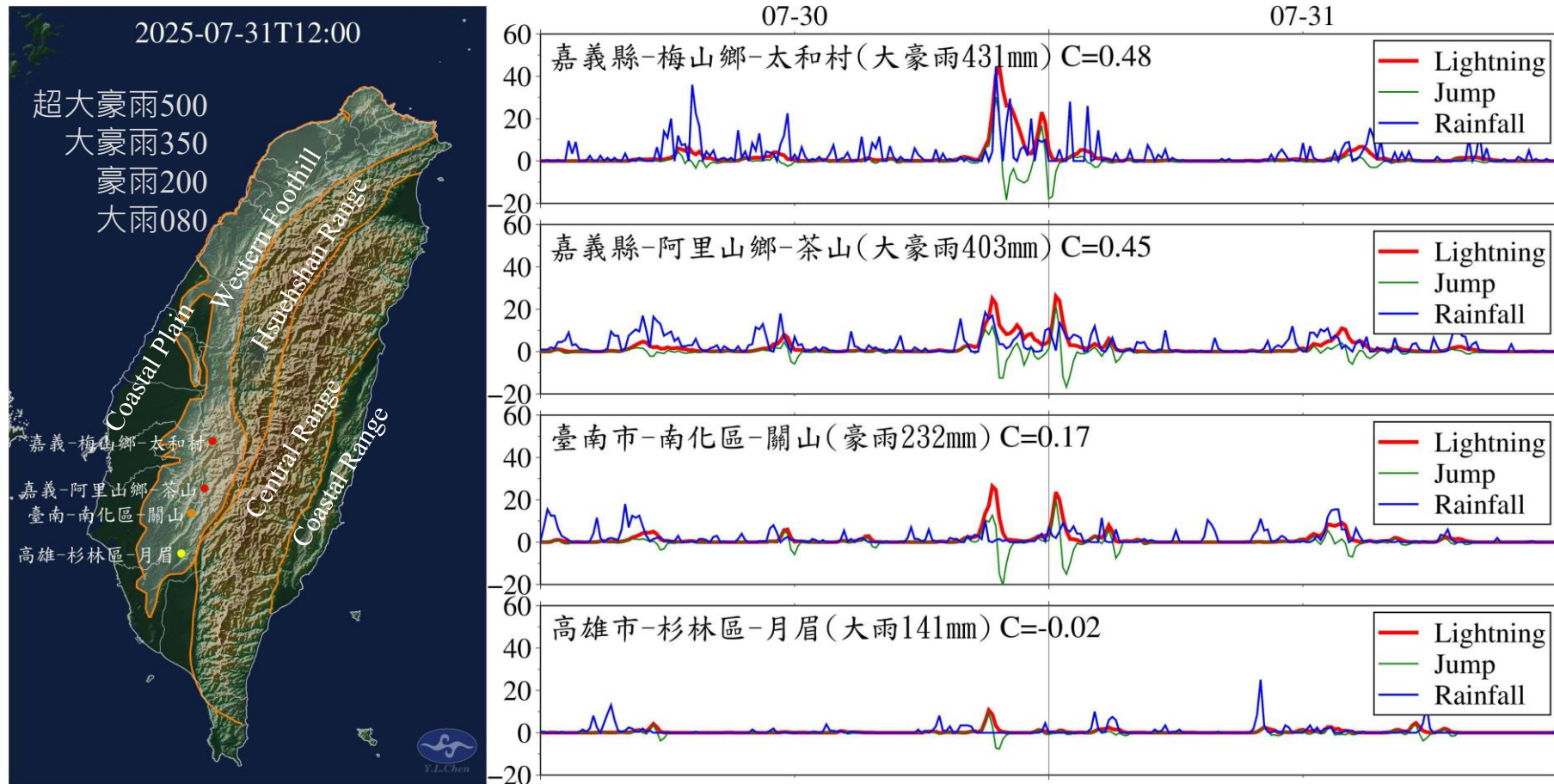
The relationship between lightning activity and rainfall in thunderstorm.



- Lightning highly correlated to severe rainfall.
- correlation of rainfall(/10 min) and lightning (/1min) mean($\pm 10\text{min}$) within 20km.



The relationship between lightning activity and rainfall in thunderstorm.

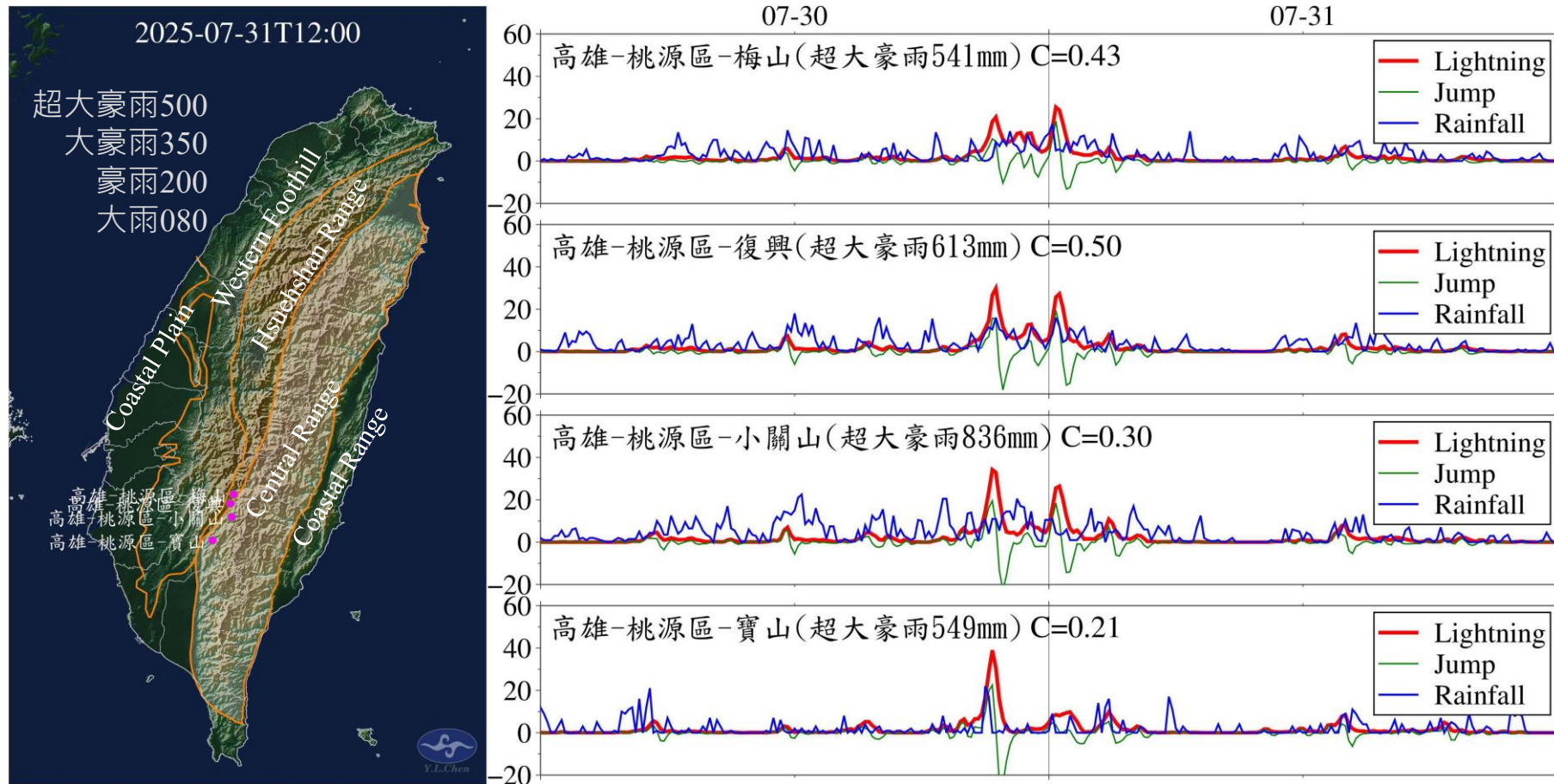


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The relationship between lightning activity and rainfall in thunderstorm.

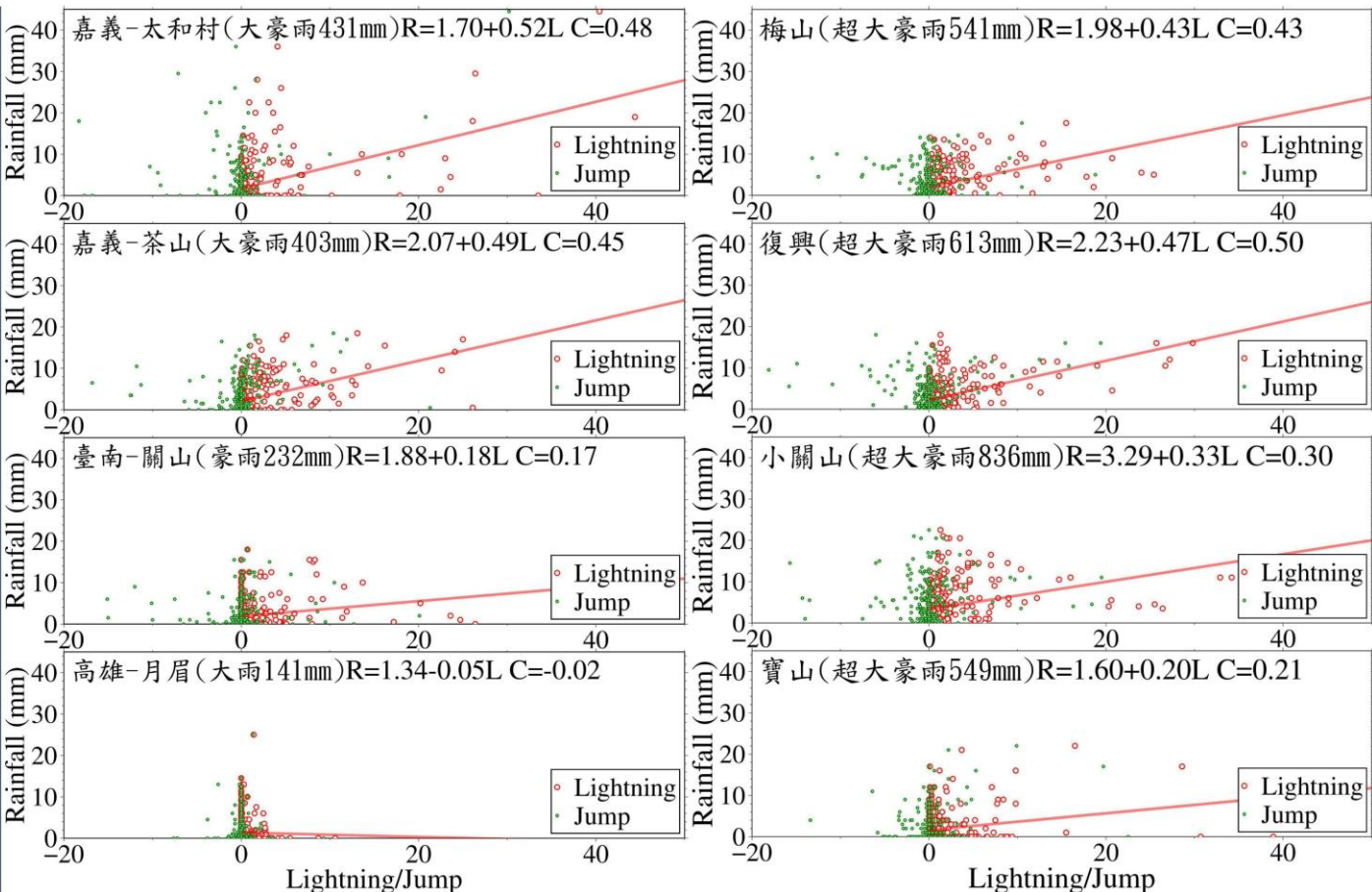
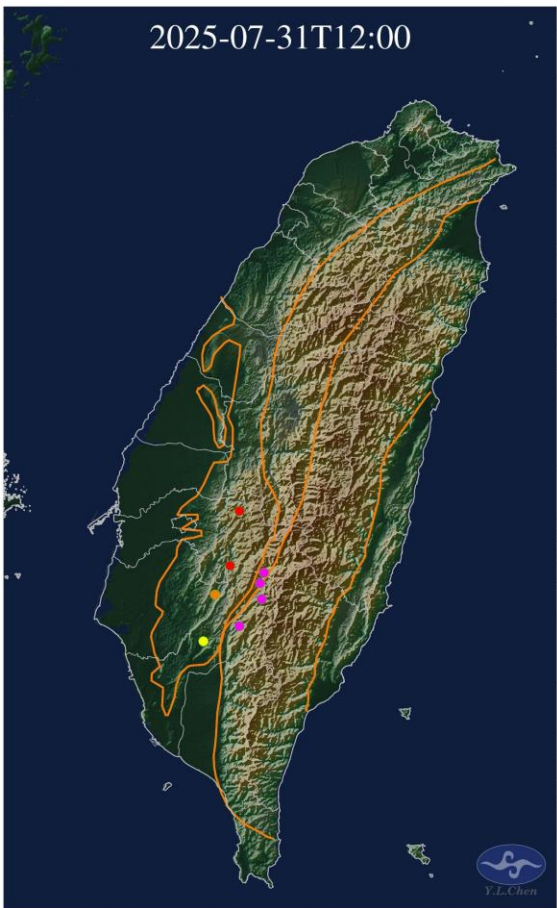


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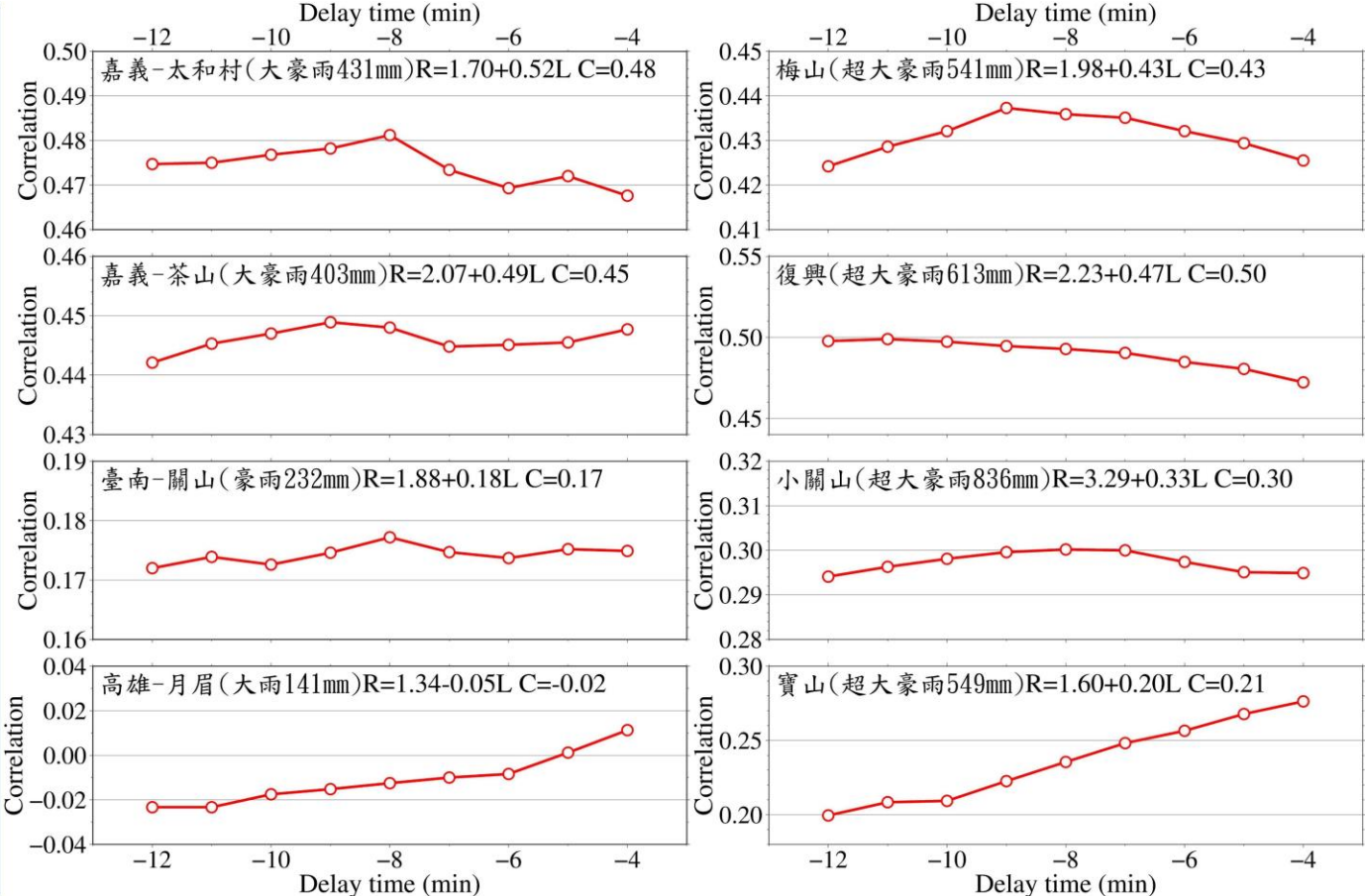
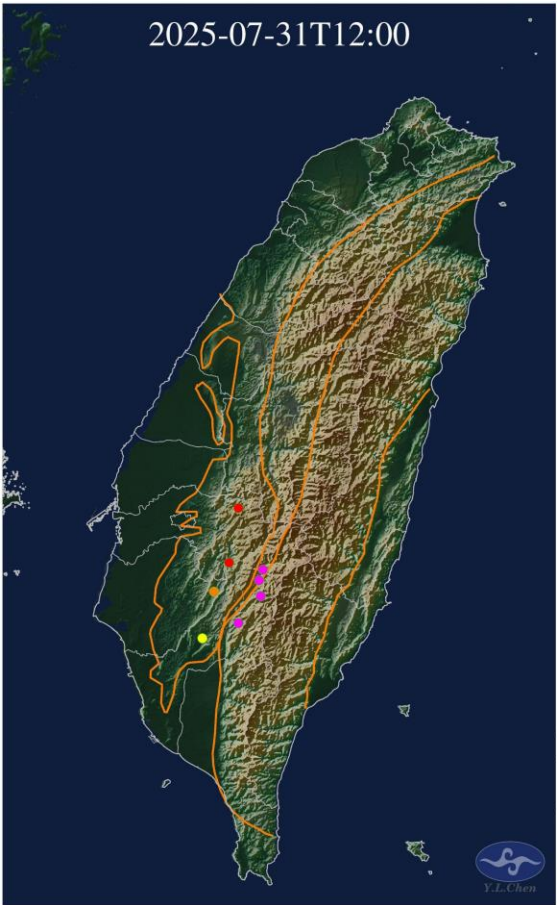


Empirical relationship between lightning and rainfall





Empirical relationship between lightning and rainfall





Summary and Thank You

1. The relationship between lightning activity and rainfall in thunderstorms.
2. The topographic effect
3. Severe convection near the mountain
4. Lightning highly correlated to severe rainfall region.

報告完畢 敬請指教

CWAOD



Y. L. Chen