

台灣西部背風渦漩發展機制及 其對空氣污染之影響

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台灣的背風渦流

Hsin-Chih Lai and Mei-Chi Lin(2020, AE)
渦流出現在925mb

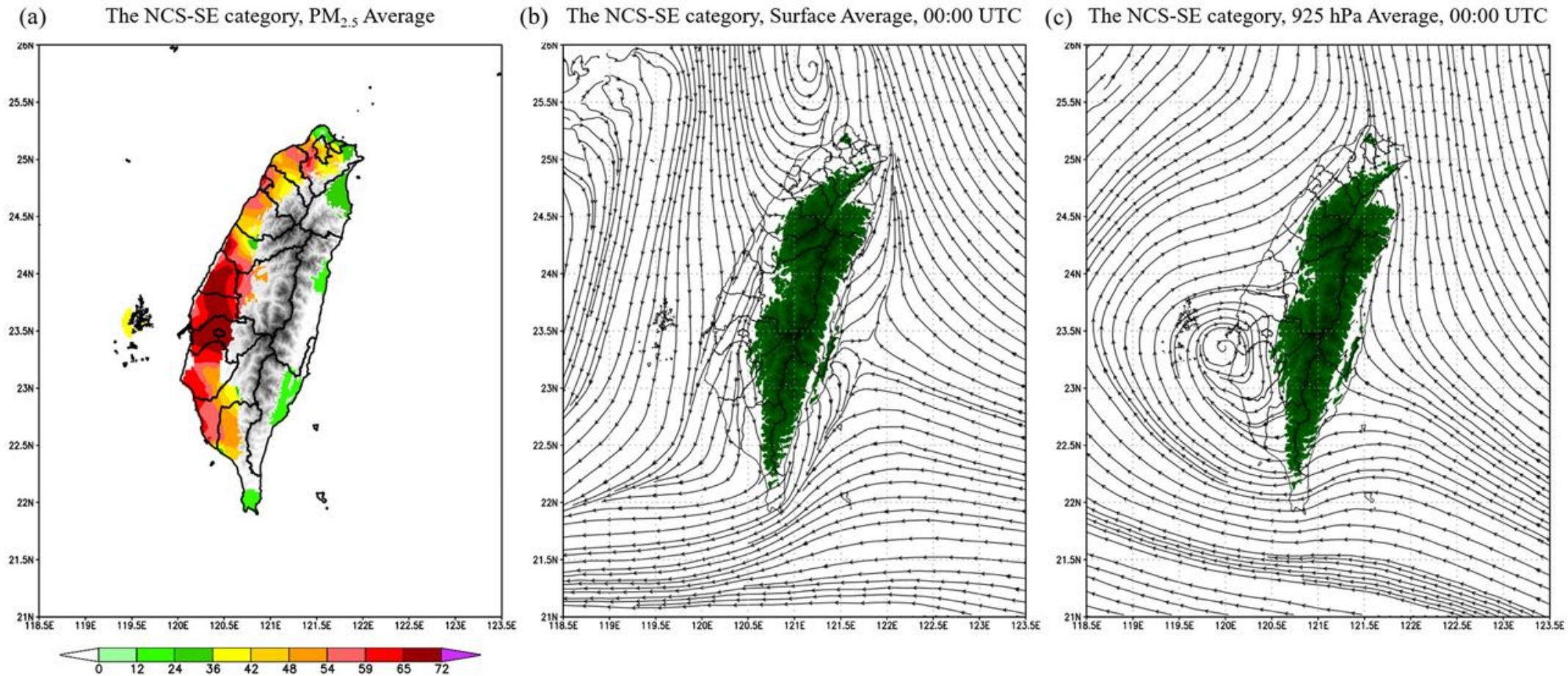


Fig. 10. PM_{2.5} concentrations and flow fields of air pollution events in the NCS-SE category. (a) Distribution of PM_{2.5} concentrations. (b) Flow field at 00:00 UTC on the surface. (c) Flow field at 00:00 UTC on the 925 hPa level. Terrain is showed by gray-color shaded from 500 m height with 500 m interval. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

東南風：台灣西北部背風渦的發展

Hsu, T.-H., Chen, W.-T.*, Wu, C.-M., & Hsieh, M.-K. (2023).

The Observation-Based Index to Investigate the Role of the Lee Vortex in Enhancing Air Pollution over Northwestern Taiwan.

Journal of Applied Meteorology and Climatology, 62(3), 427-439. <https://doi.org/10.1175/JAMC-D-22-0102.1>

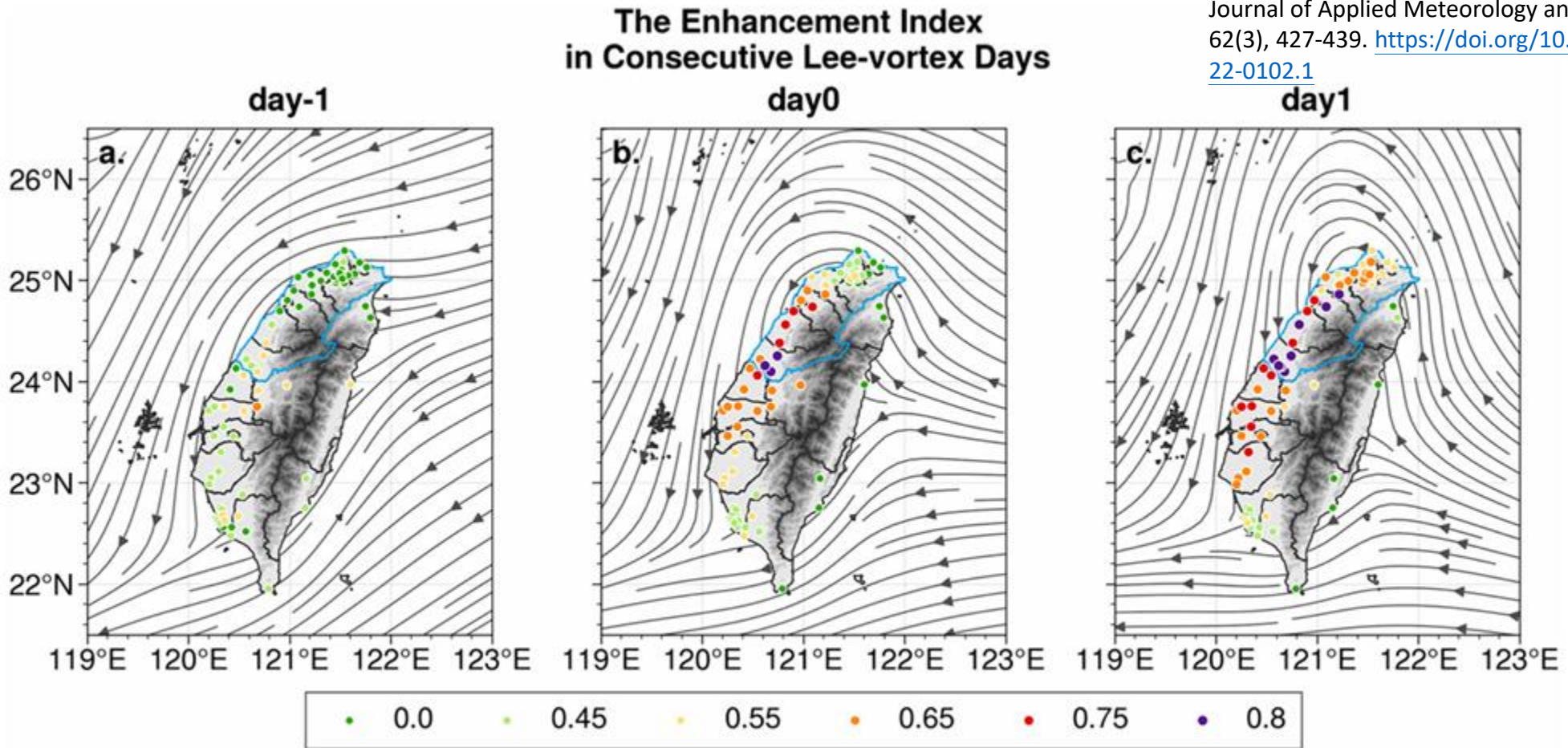
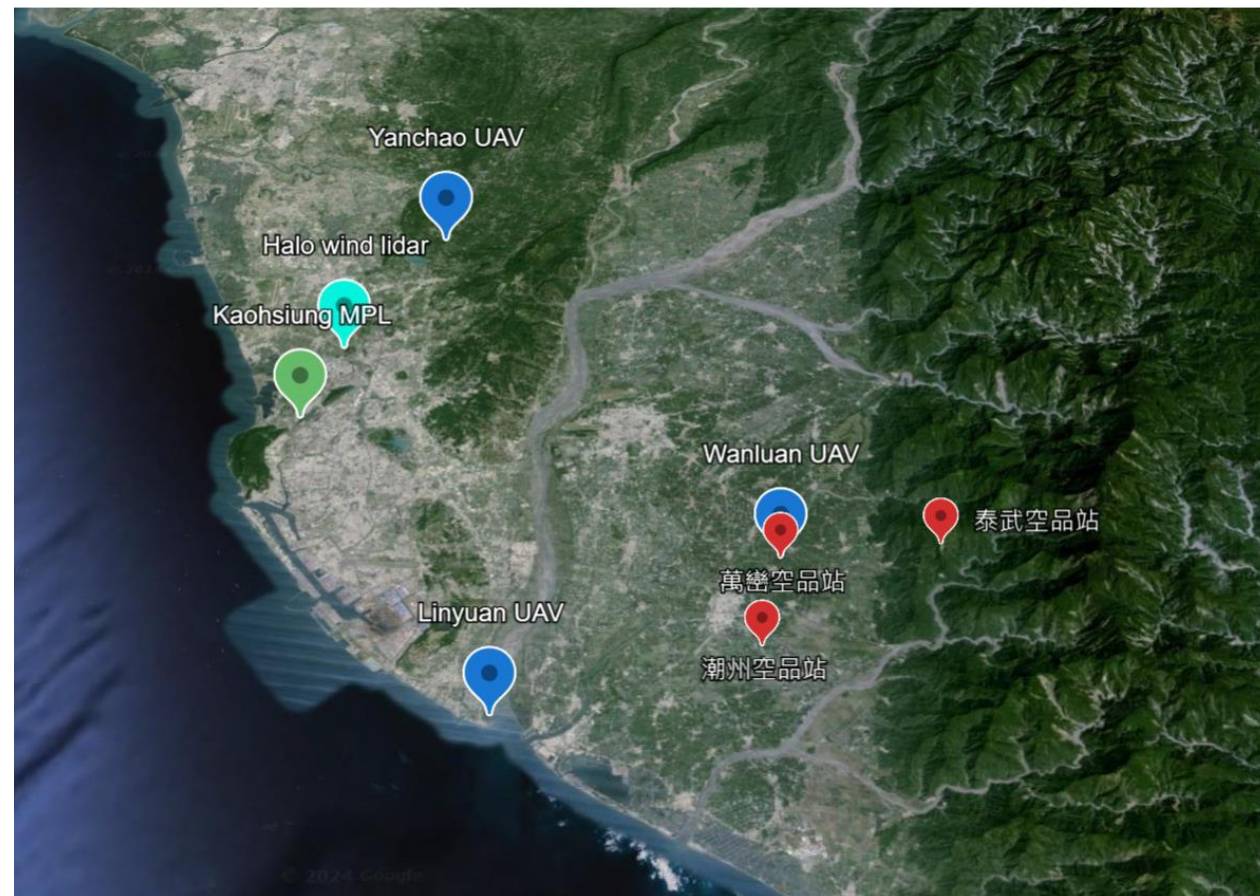
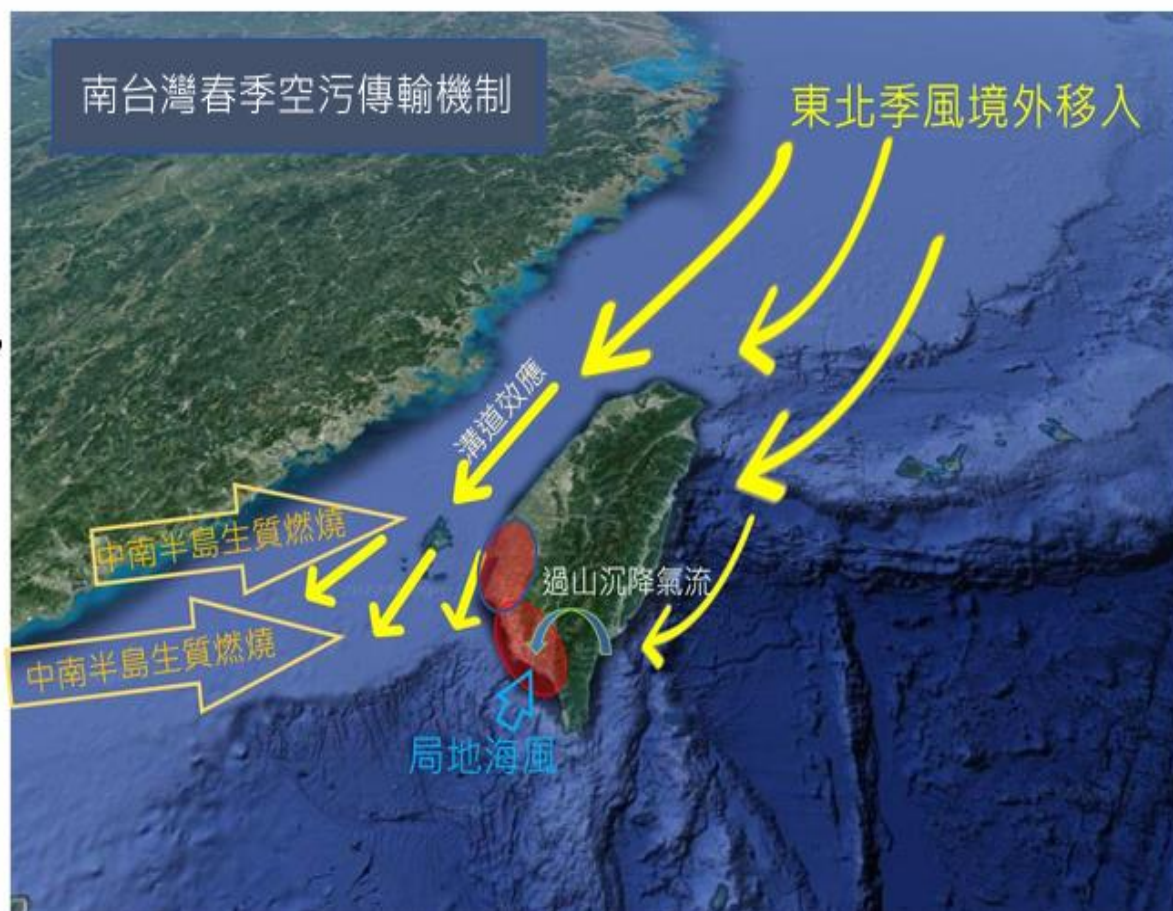
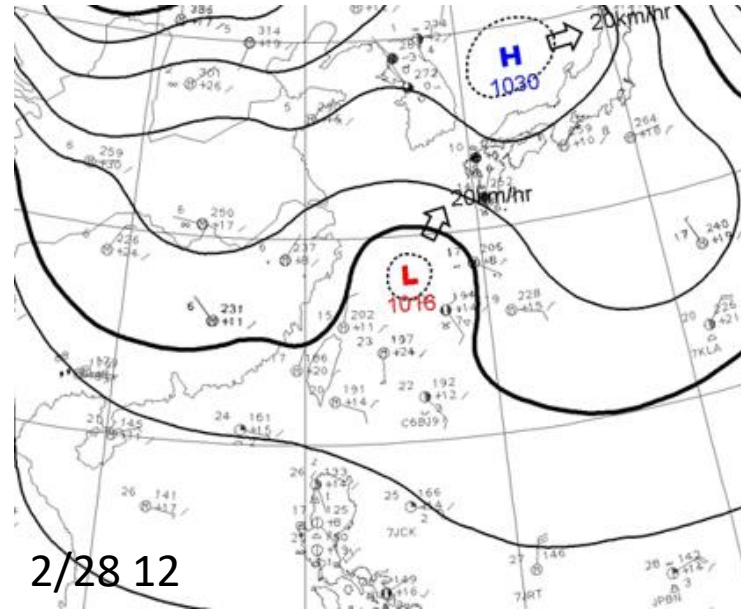
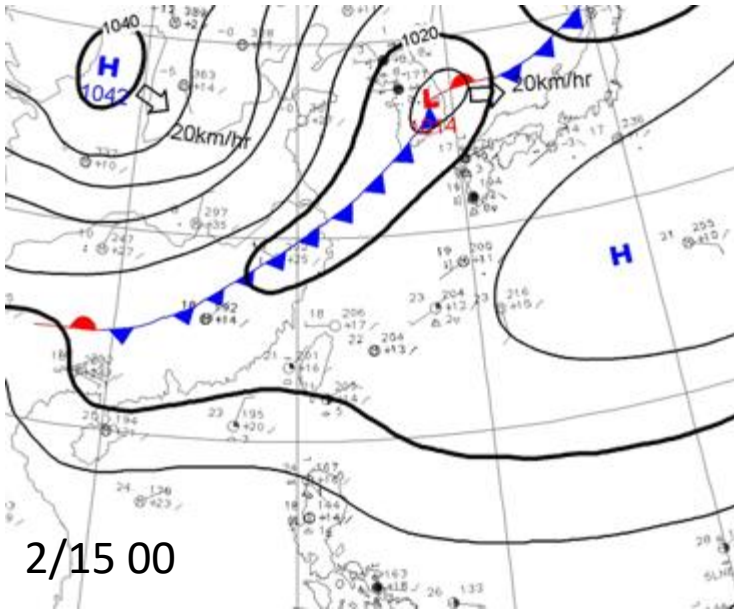


FIG. 9. As in Fig. 5b, but for the enhancement indices (colored dots) at the 74 EPA stations and the composite mean daily 10-m wind from ERA5 (streamlines) on (a) day -1, (b) day 0, and (c) day 1 of the consecutive lee-vortex days.

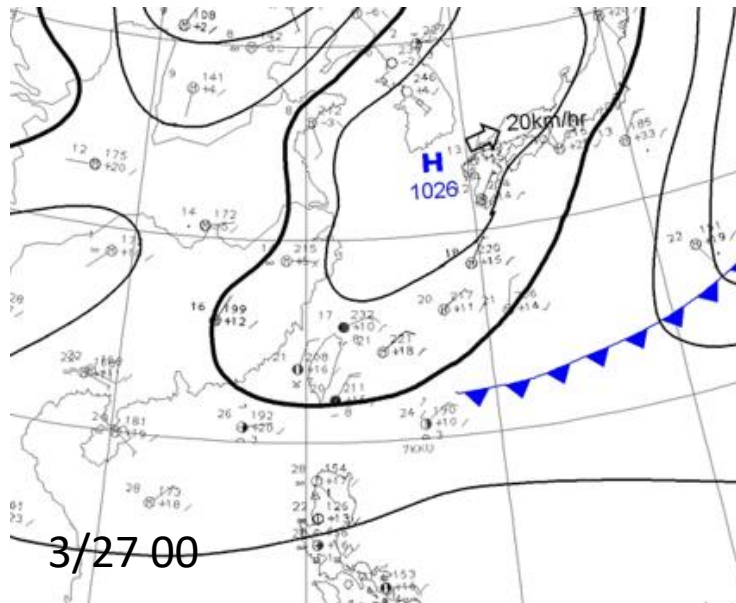
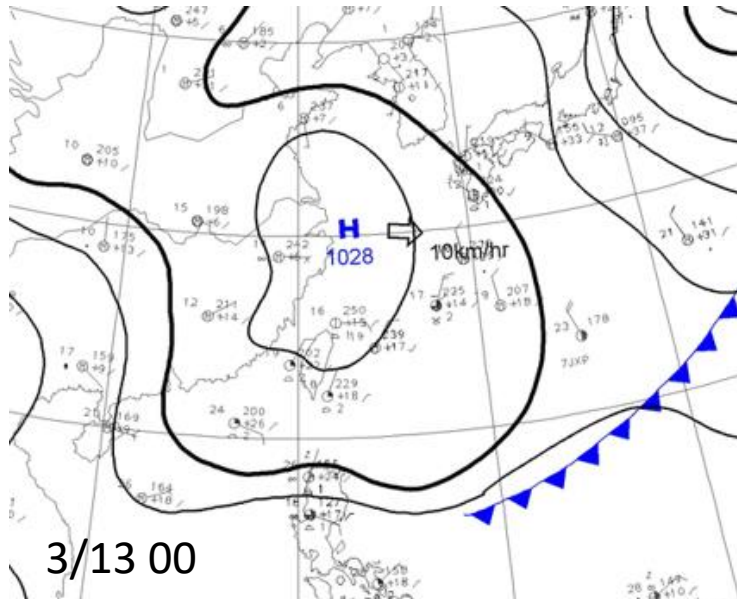
2024年KPEx高屏環流觀測實驗- 地形引發三維氣流對空汙傳送效應



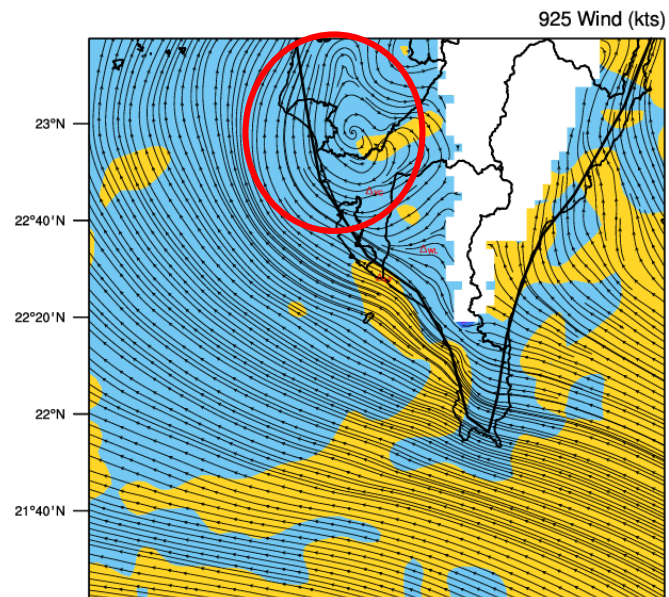
(引自林能暉教授、王聖翔教授簡報檔)



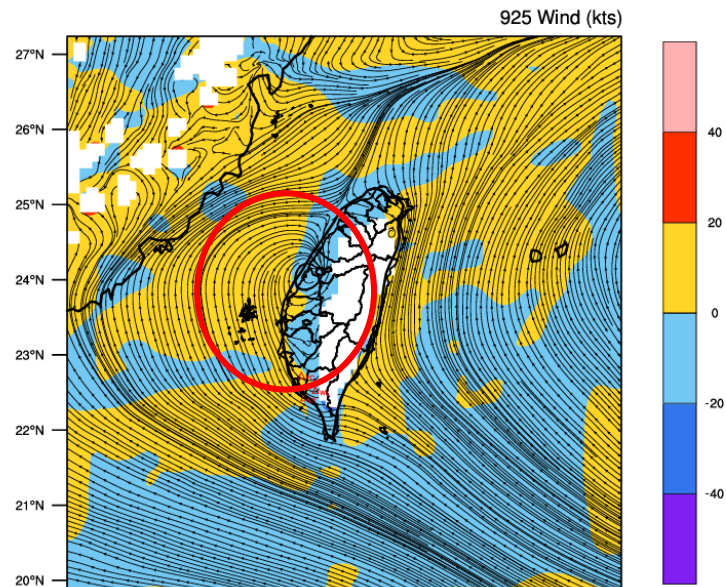
2/15 High pressure reverse flow
 2/28 cold air flow
 3/13 high pressure flows out to sea
 3/27 high pressure flows out to sea



2024021508

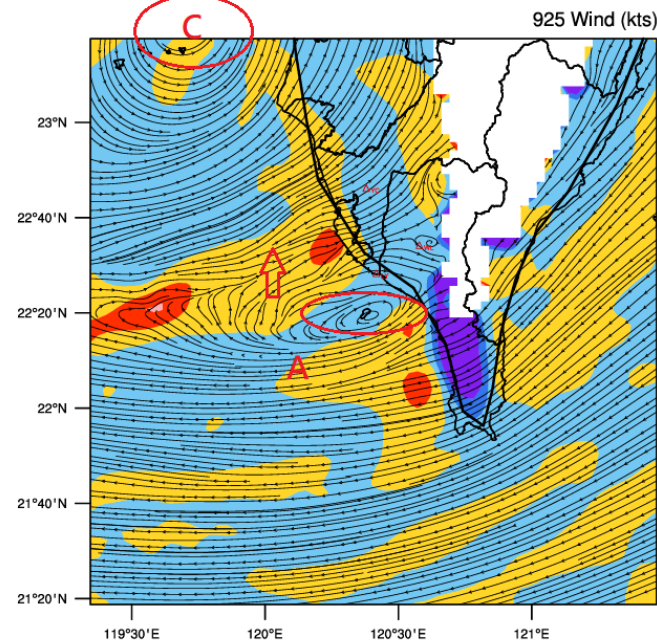


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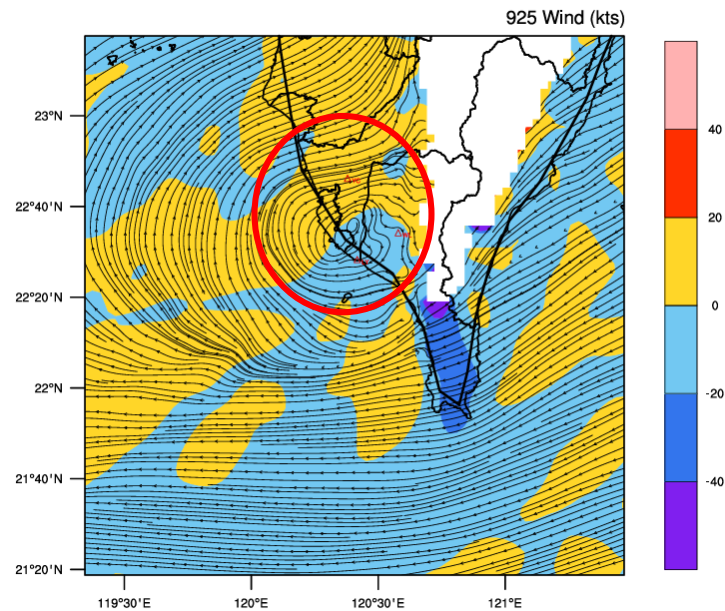


2/15 2/28 3/13 3/27 都有背風渦漩

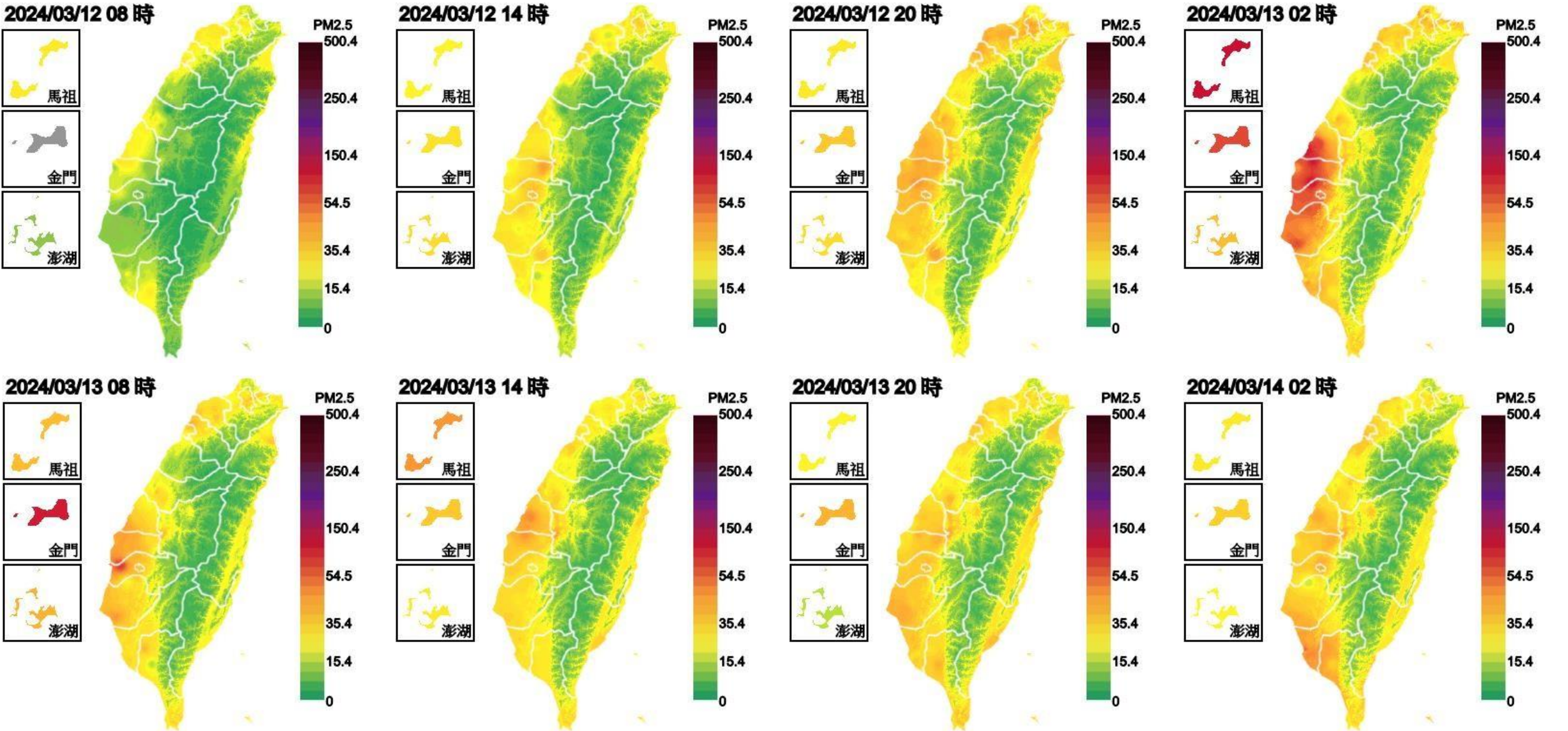
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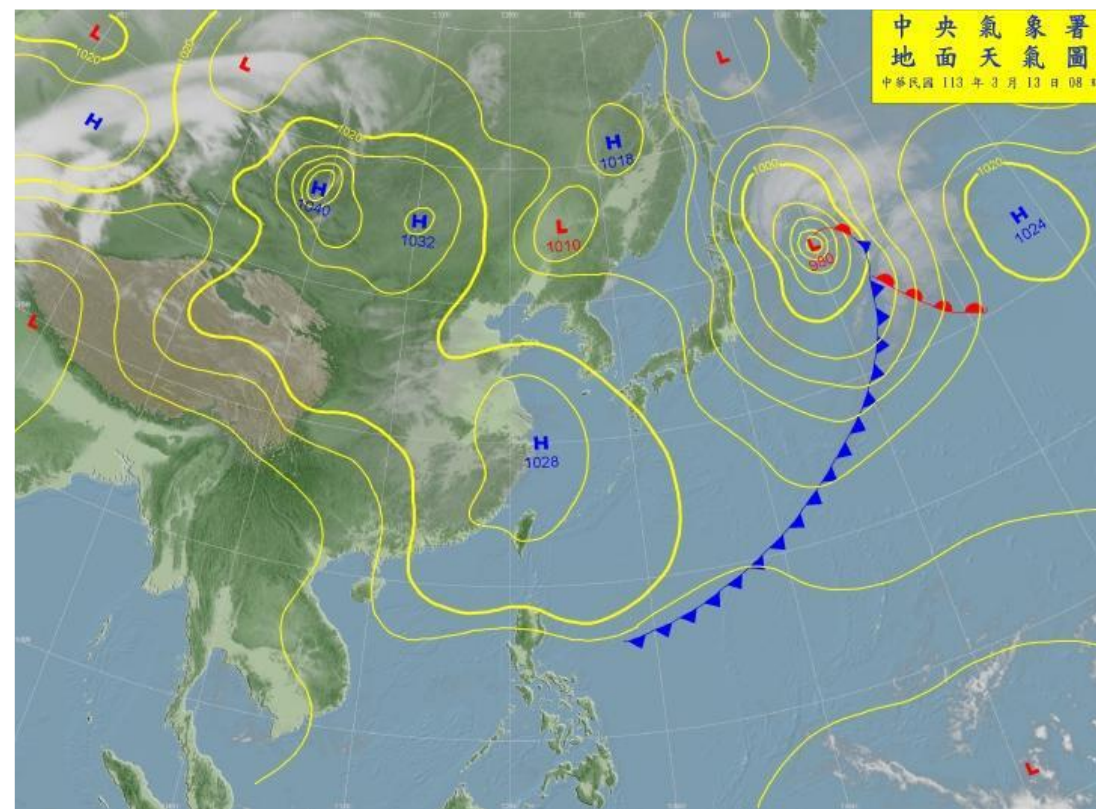
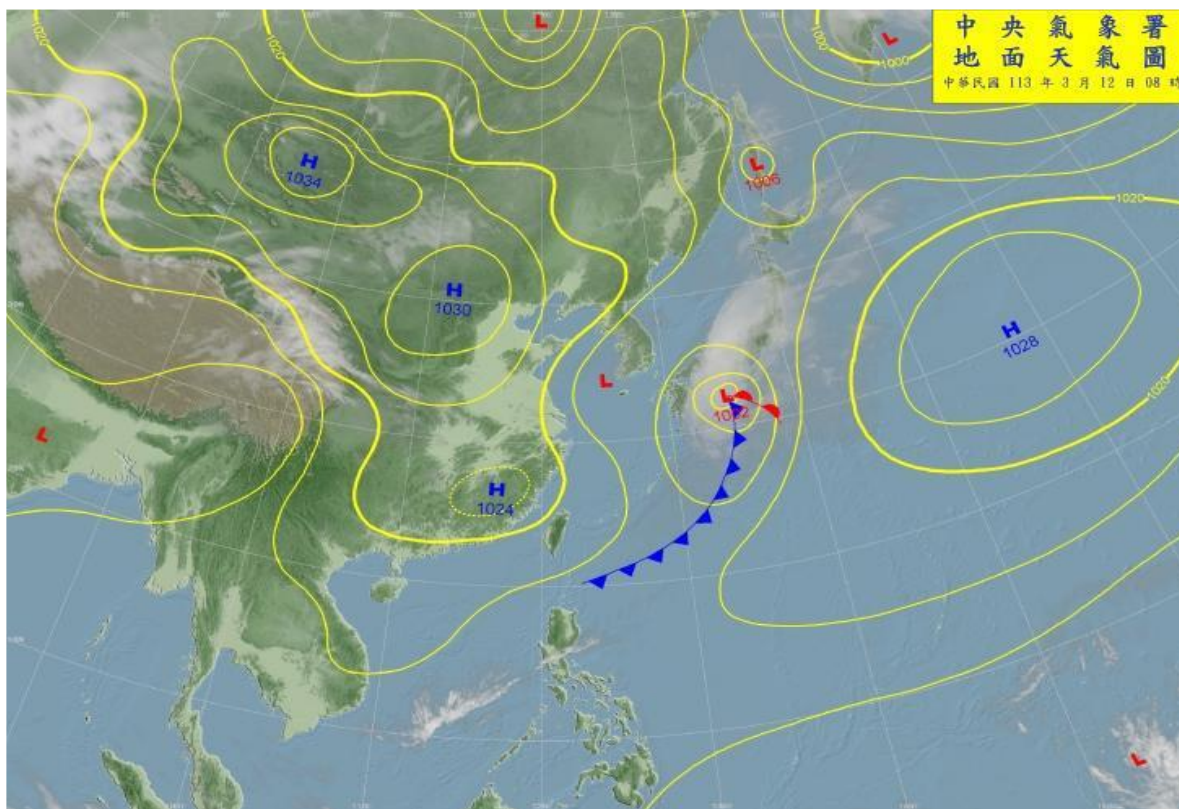
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IOP 3:3月12日，中部和北部地區出現稍微偏高的濃度，下午其他地區的濃度也開始上升。3月13日，整個台灣西部的濃度開始增加。

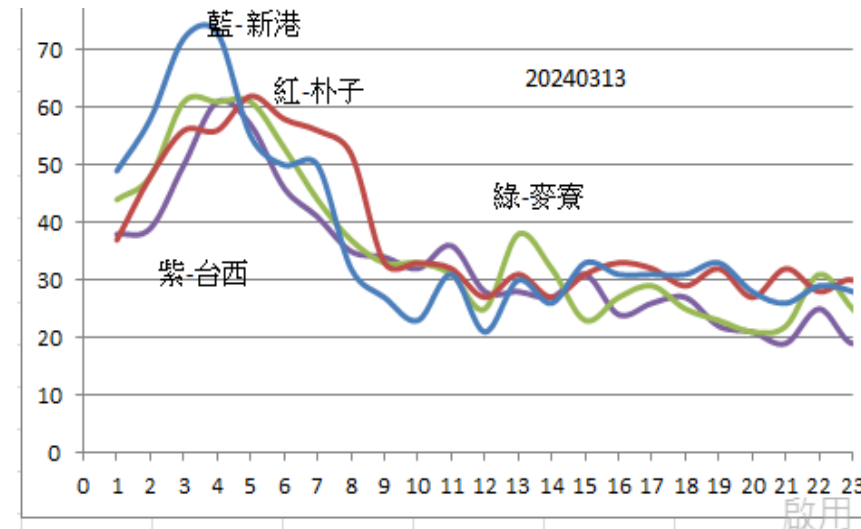
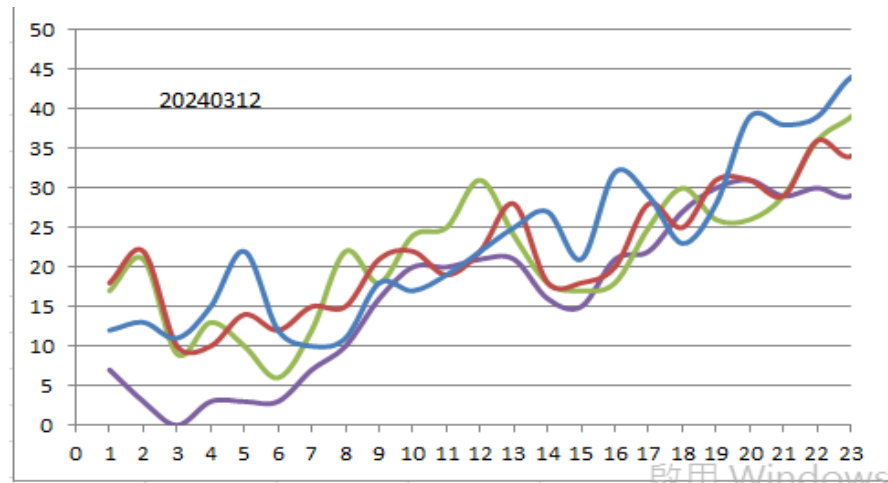
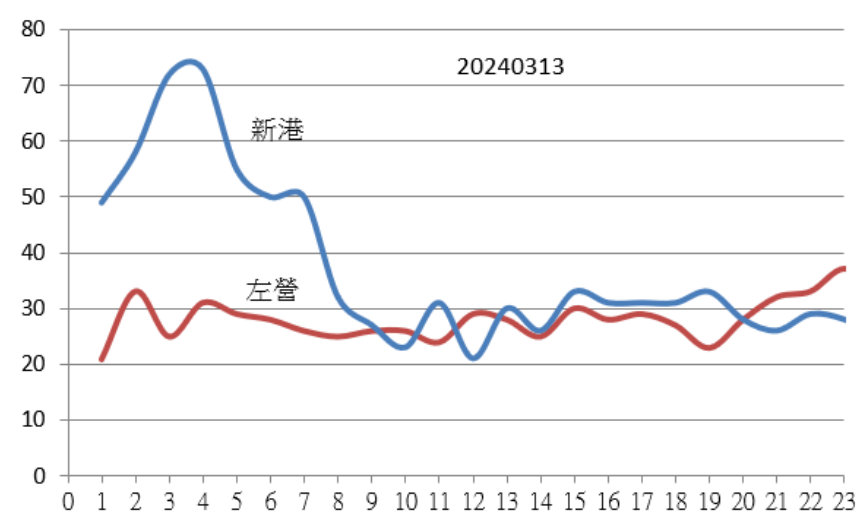
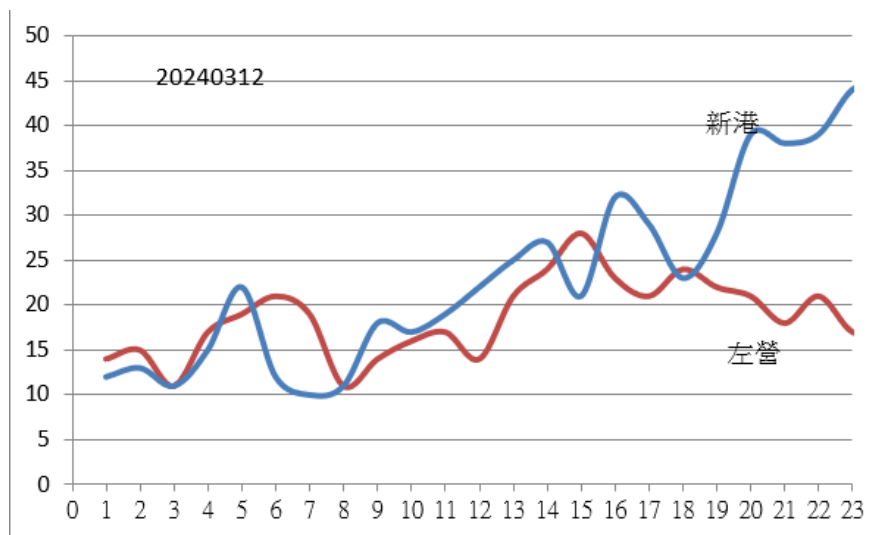


雲林、嘉義PM2.5濃度突然升高原因為何？

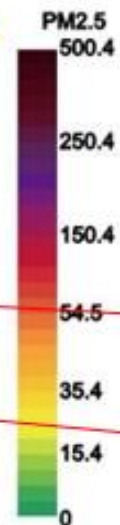
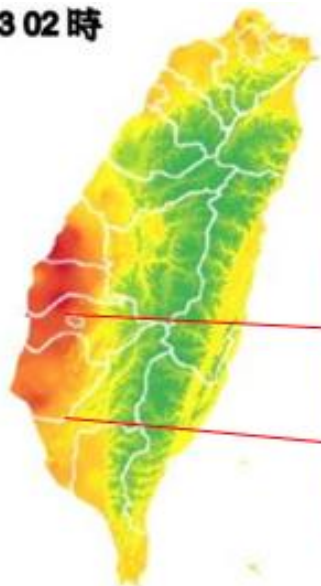


綜觀天氣分析：12日受鋒面通過及大陸冷氣團南下影響、13日受高壓出海影響，影響台灣空氣品質型態，但高屏地區空品並未惡化。

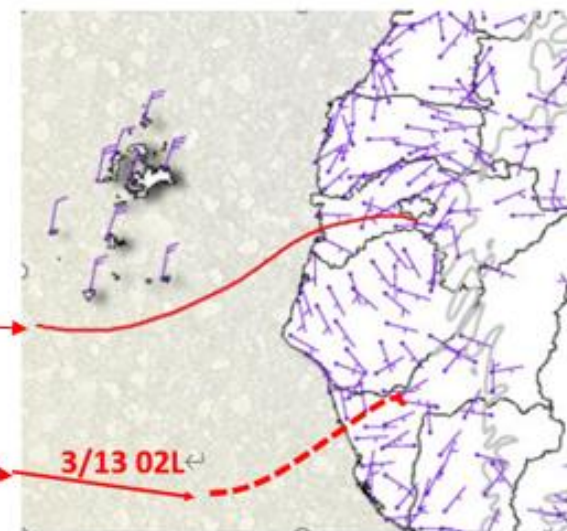
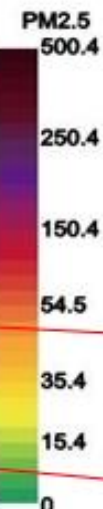
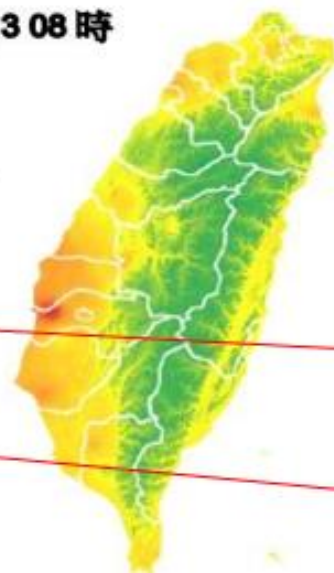
高屏地區左營PM2.5在3/12白天與嘉義新港濃度接近。
3/12夜間至3/13清晨五點新港濃度明顯高於高雄左營。



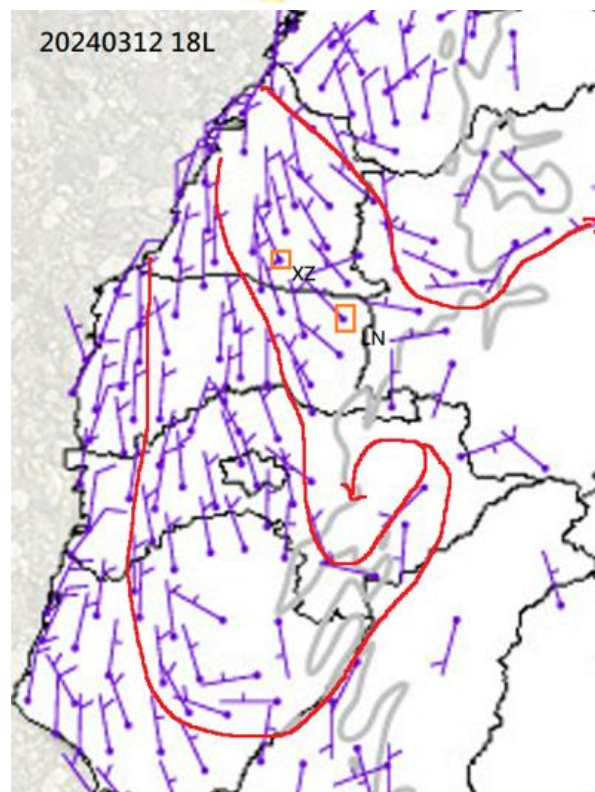
2024/03/13 02 時



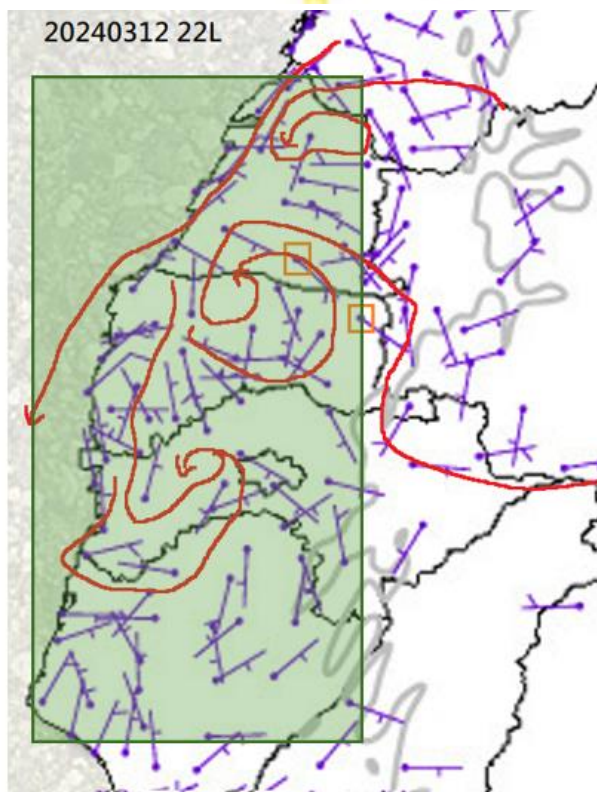
2024/03/13 08 時



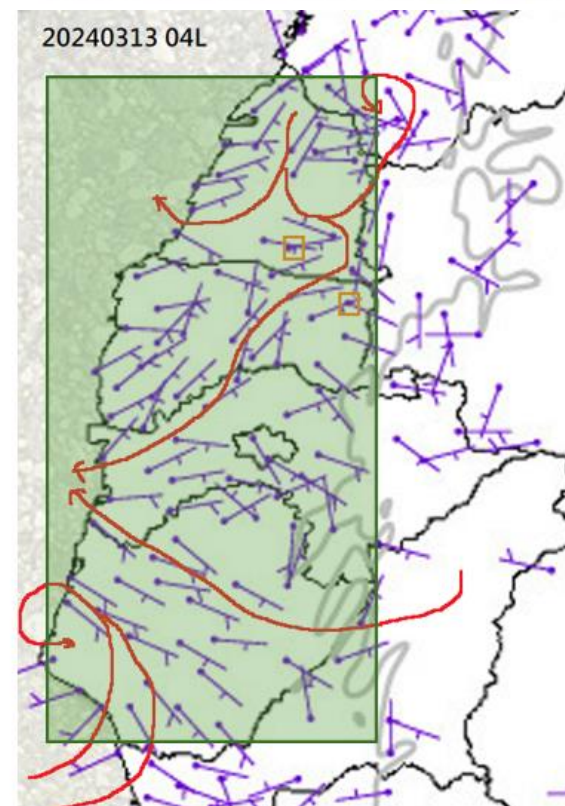
20240312 18L



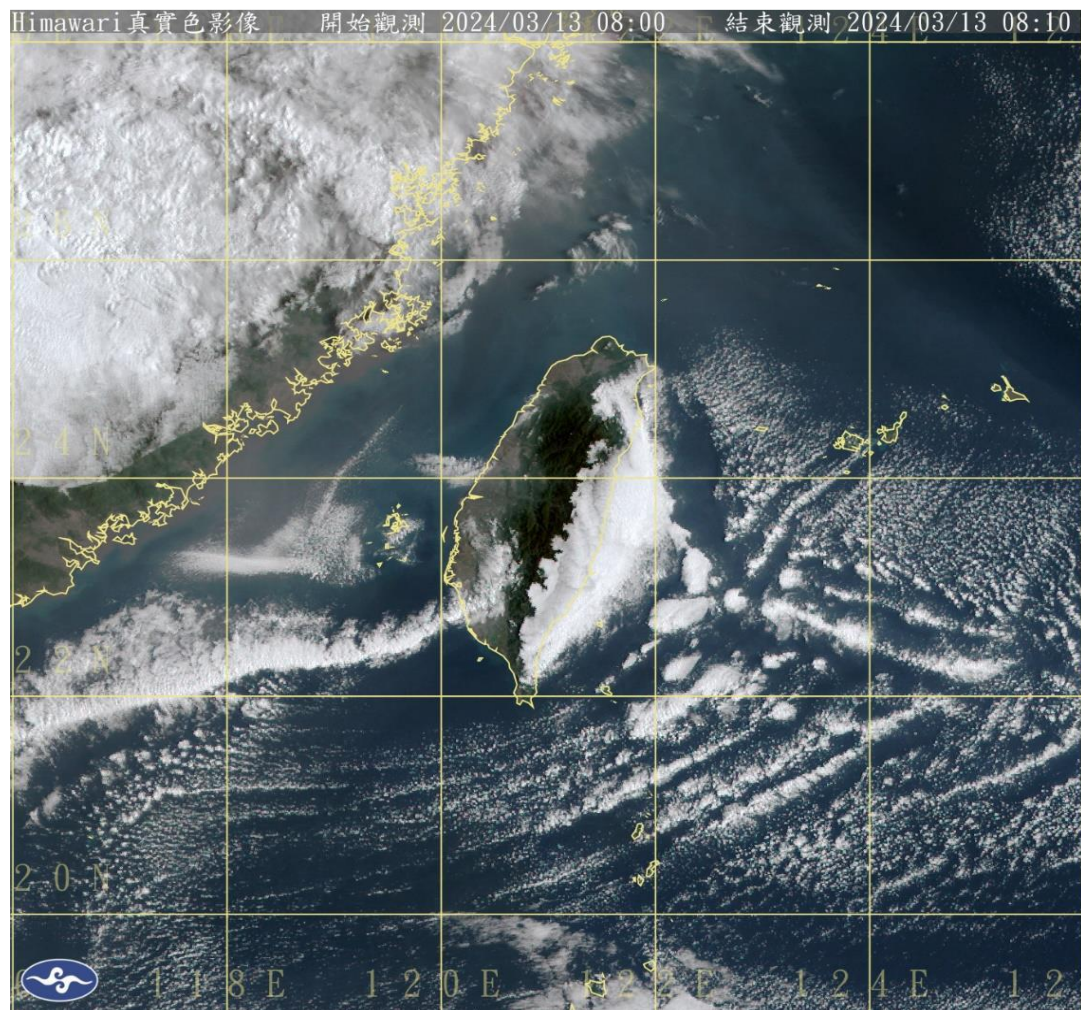
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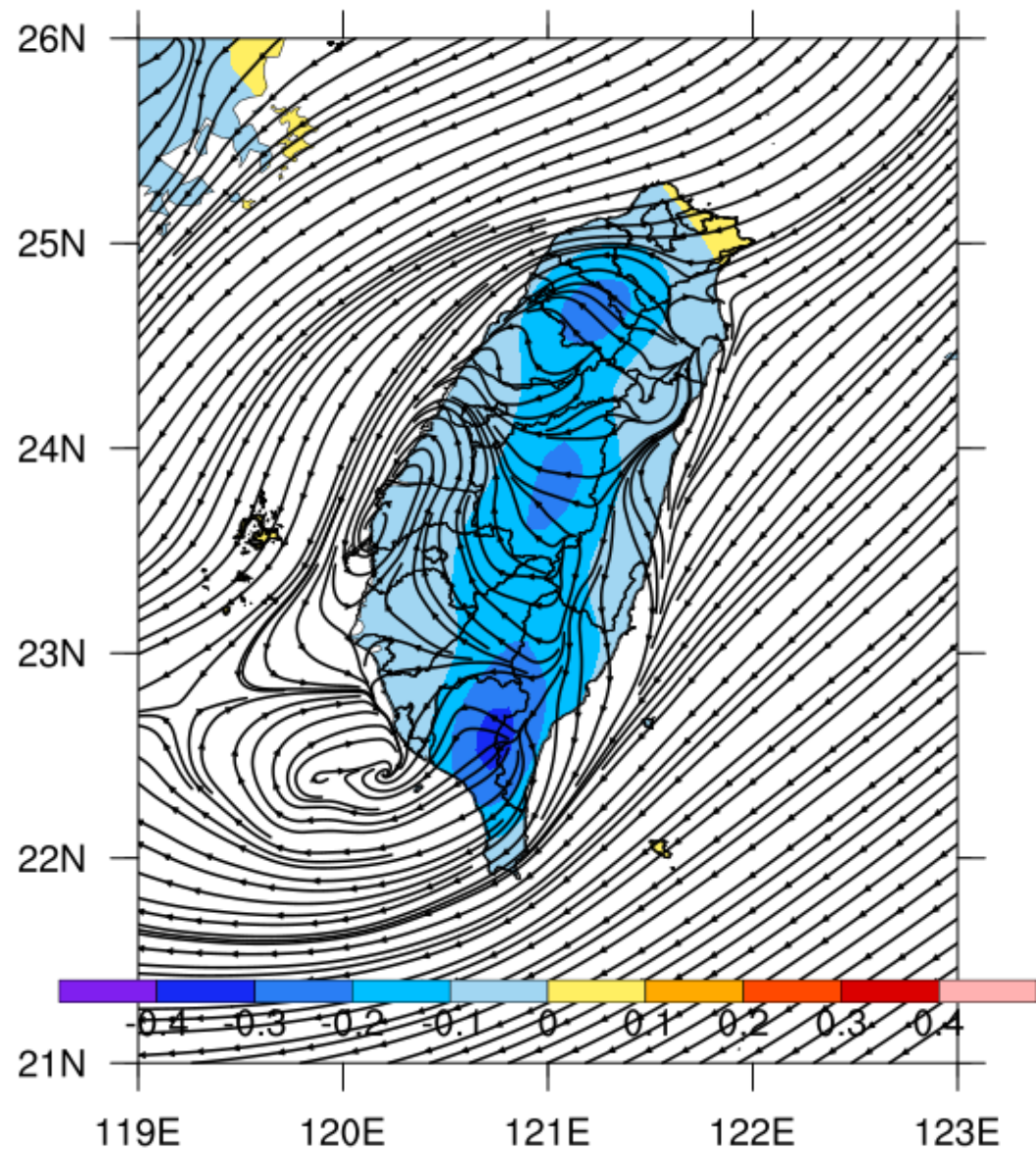
20240313 04L



The shaded area indicates the region where surface $\text{PM}_{2.5}$ concentrations gradually increased.



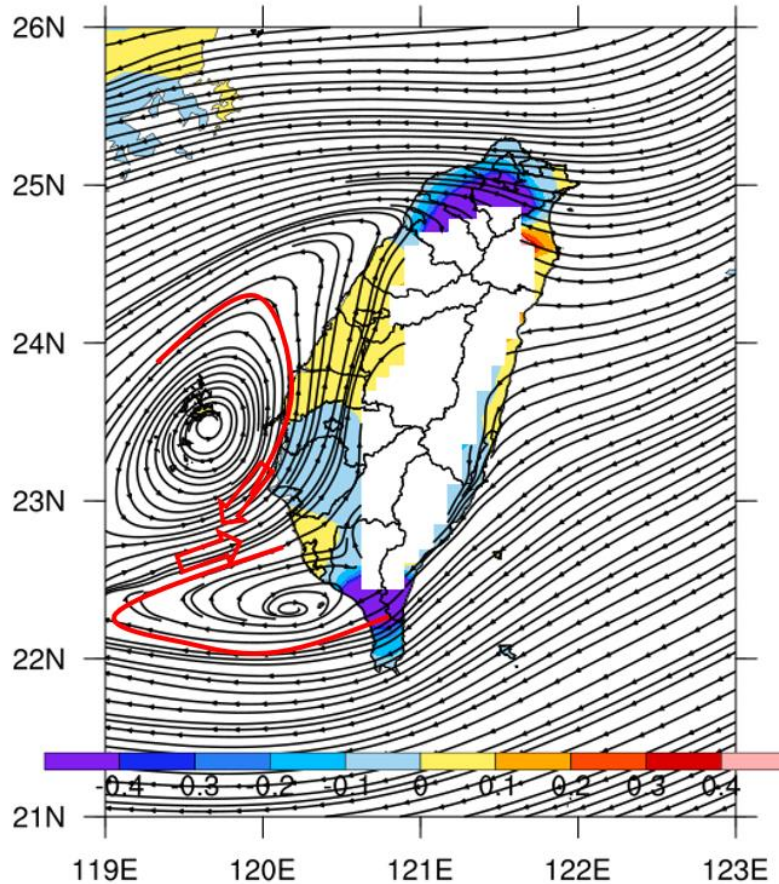
2024/3/13 08L (大氣水文資料庫)



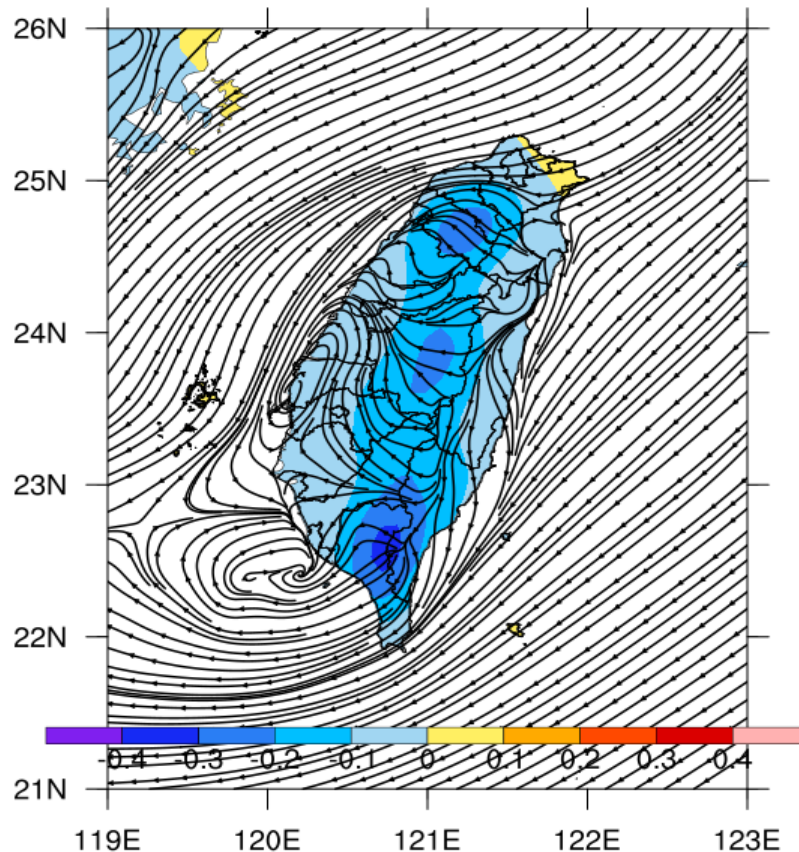
2024/3/13 02L (WRF)

背風渦旋存在於地面至700多公尺

3/13 04L
925 mb

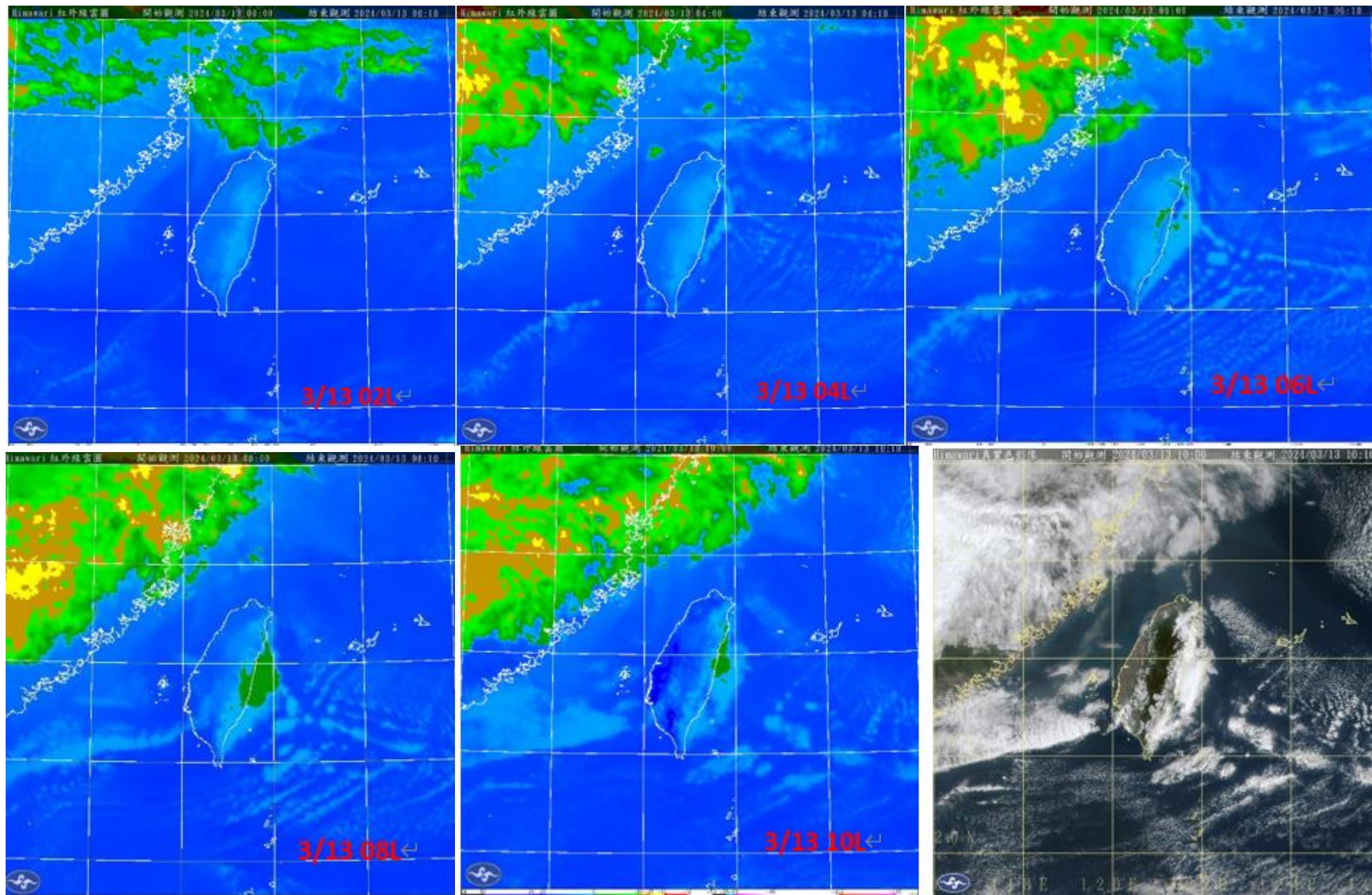


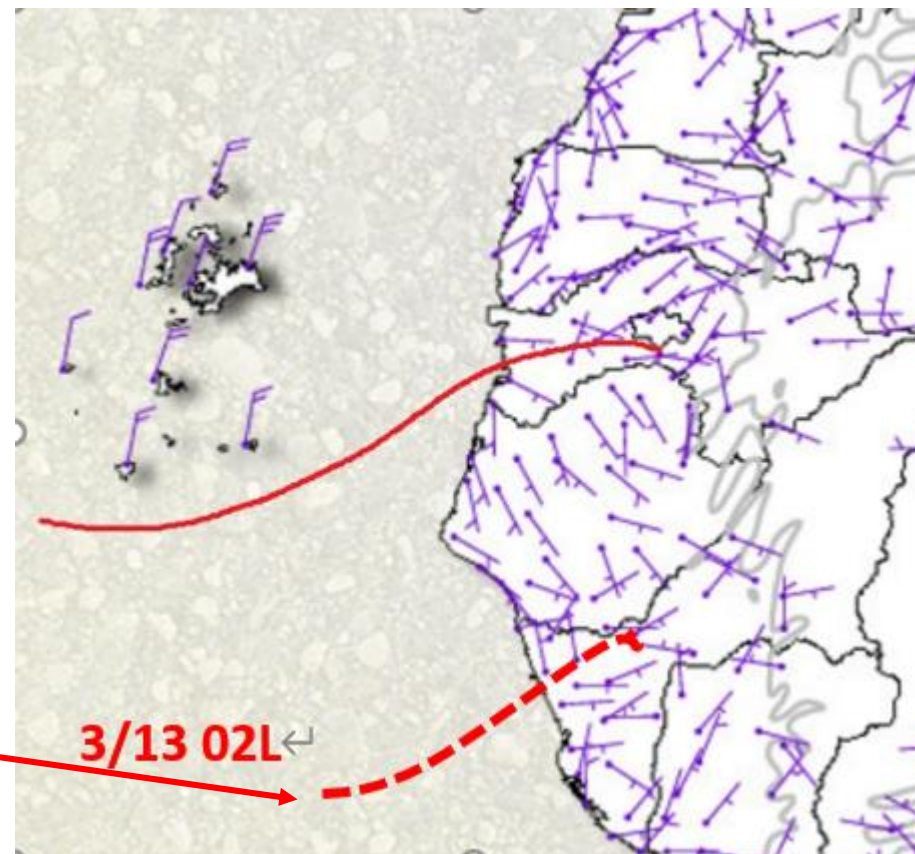
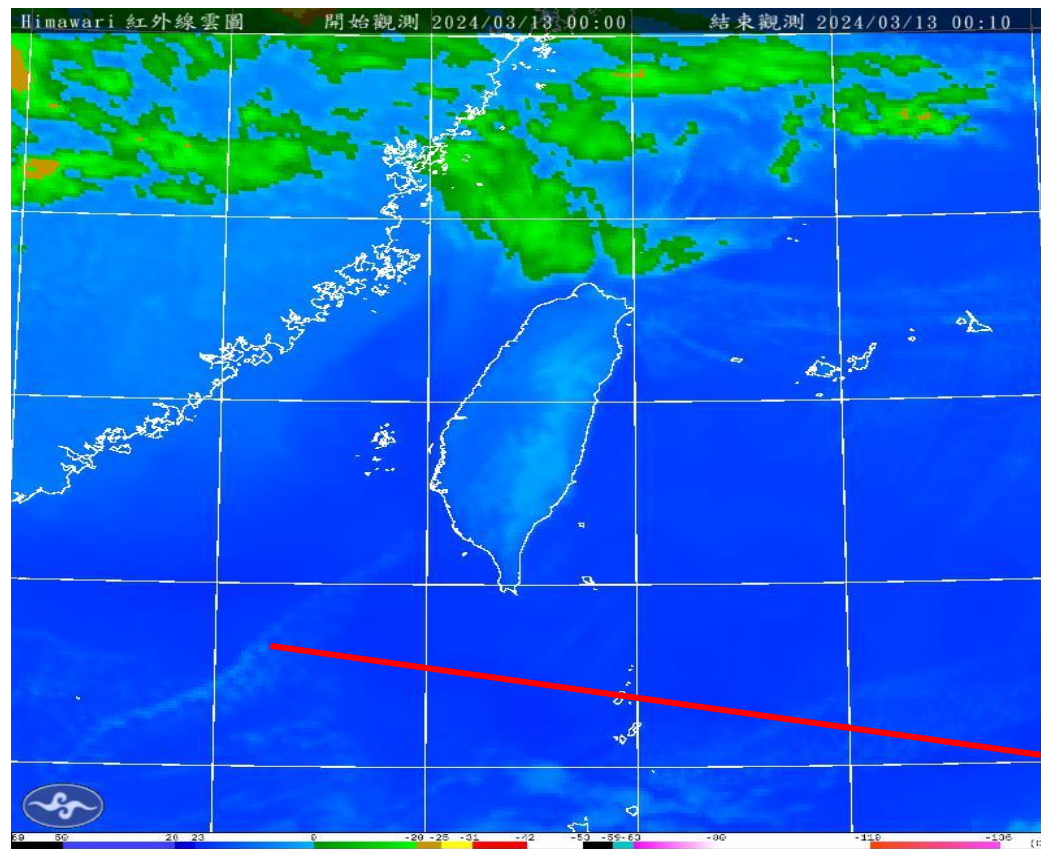
3/13 02L
sfc



Following the passage of a cold front, a narrow convective cloud band developed along the Tainan–Kaohsiung border, which was successfully reproduced by the WRF model as a terrain-induced leeside vortex. However, the highest PM_{2.5} concentrations occurred from Changhua to Tainan rather than within the convective convergence zone. These results suggest that PM_{2.5} accumulation was more closely associated with the Chiayi shear line, local circulations over the Changhua–Yunlin region, and boundary-layer evolution than with the convective cloud band itself.

台南高雄外海對流雲帶持續存在

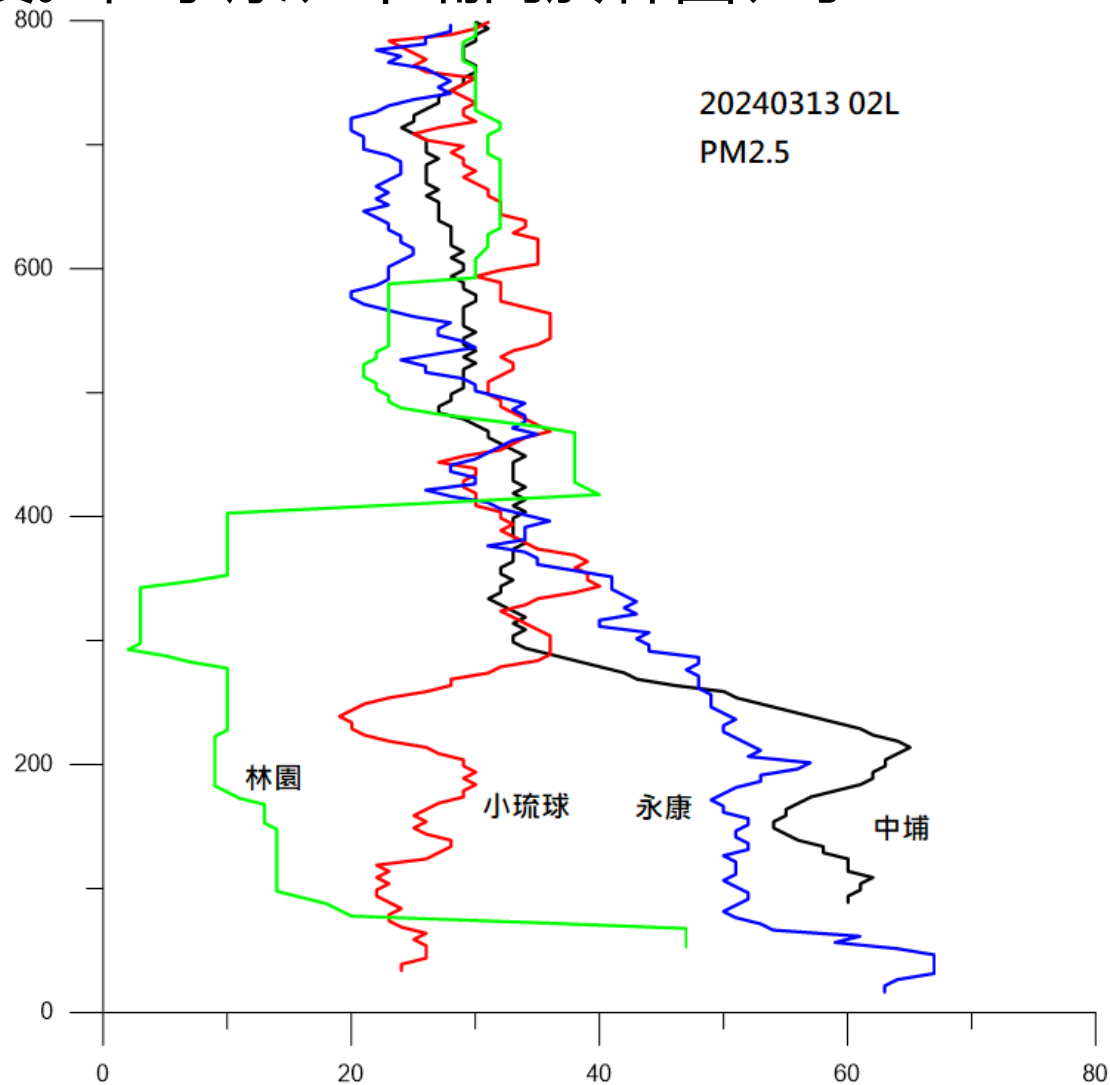
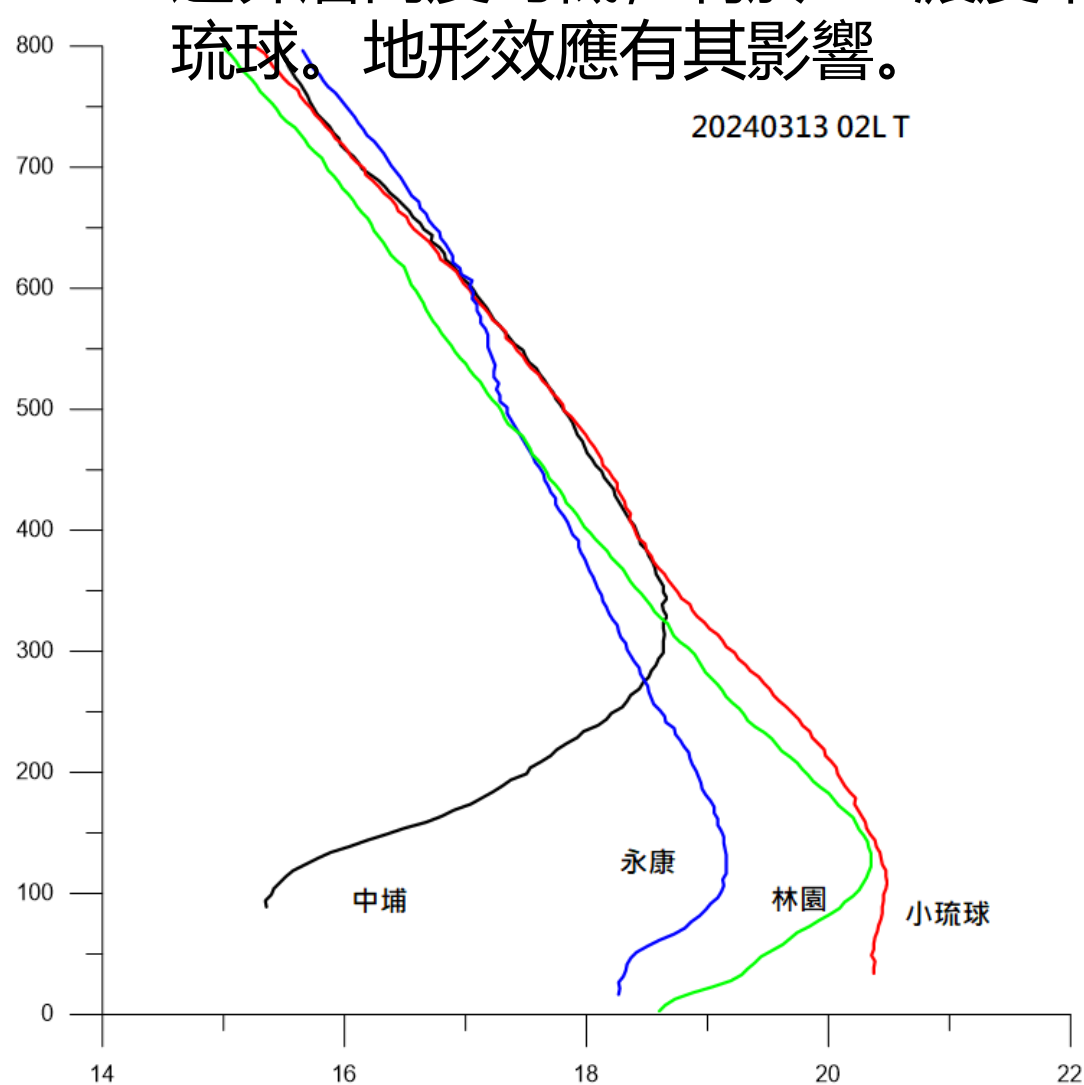




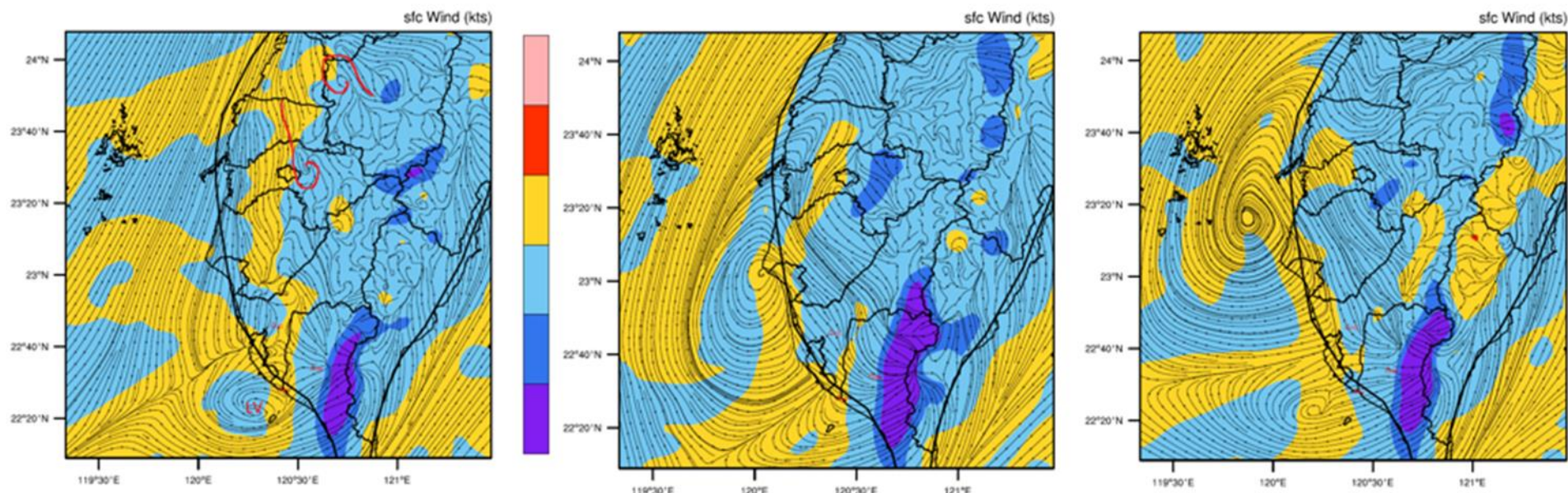
雲系為背風渦旋產生合流所致

嘉義中埔逆溫高350m，高雄林園150m，台南永康100m，小琉球120m

邊界層高度均低，利於PM濃度堆積。但永康、中埔高於林園、小琉球。地形效應有其影響。

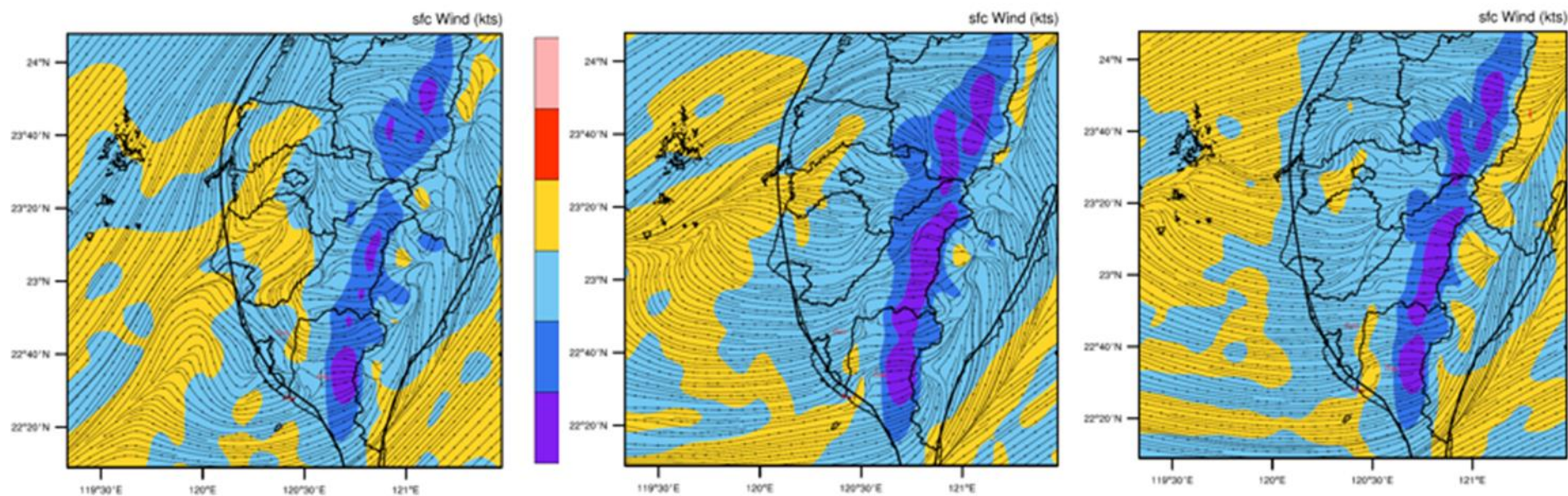


控制
模式



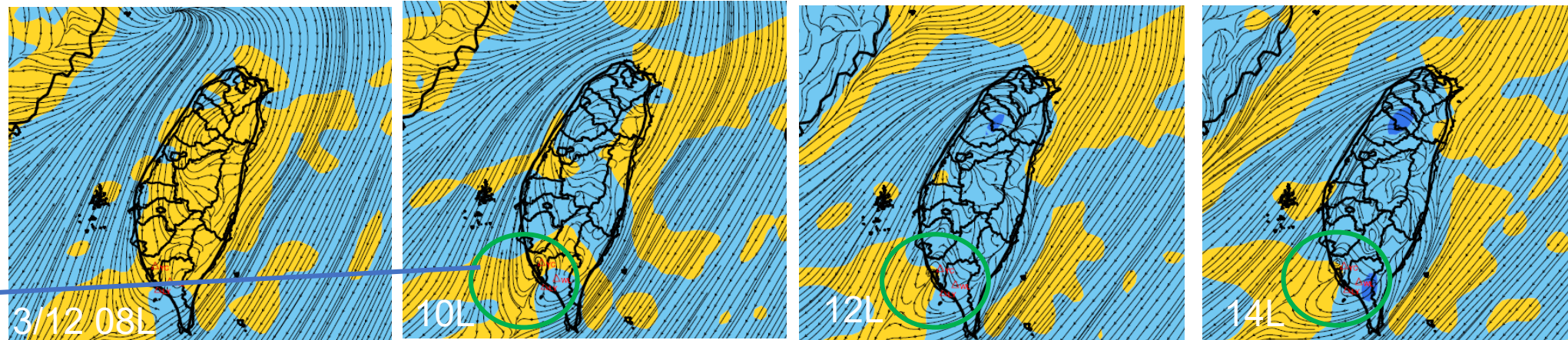
at 2000 LST 12 March, 0400 LST, and 0800 LST 13 March 2024.

地形
減半

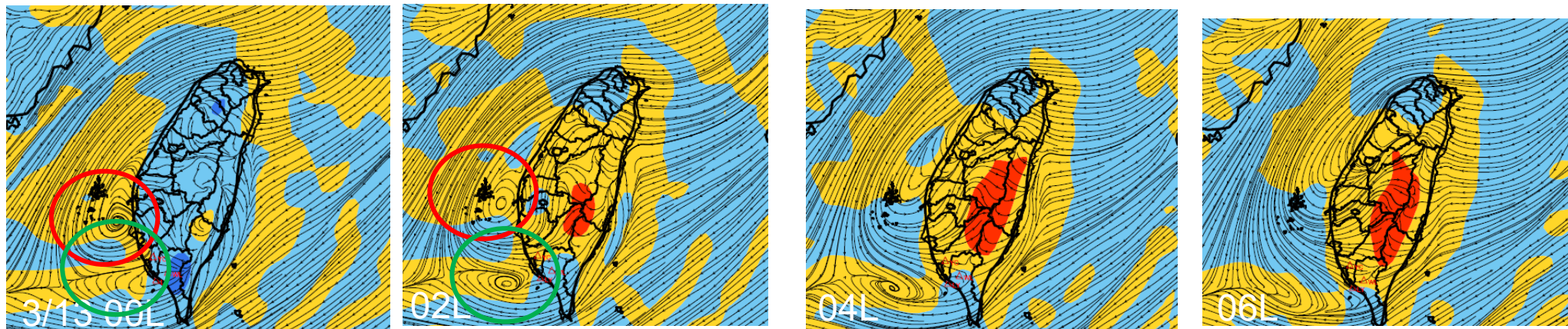
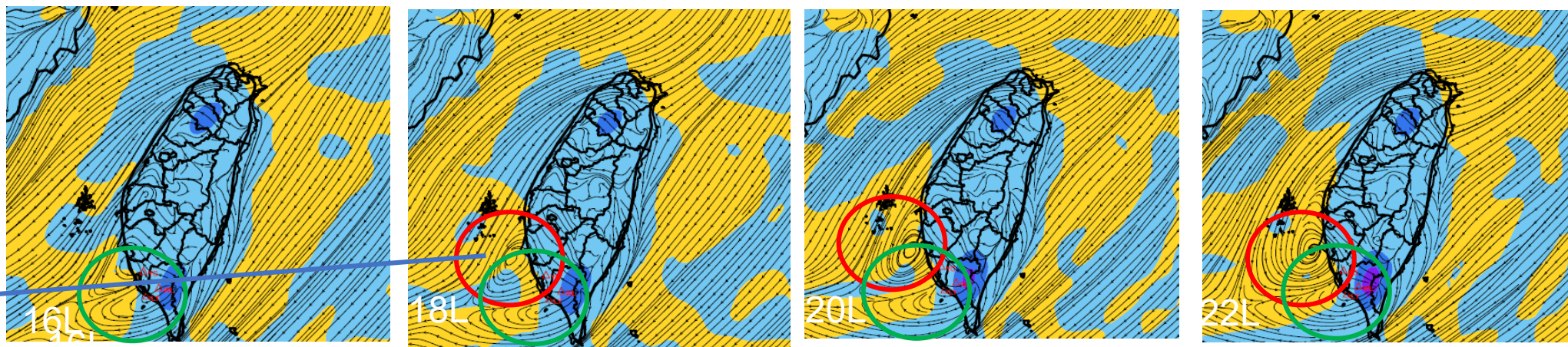


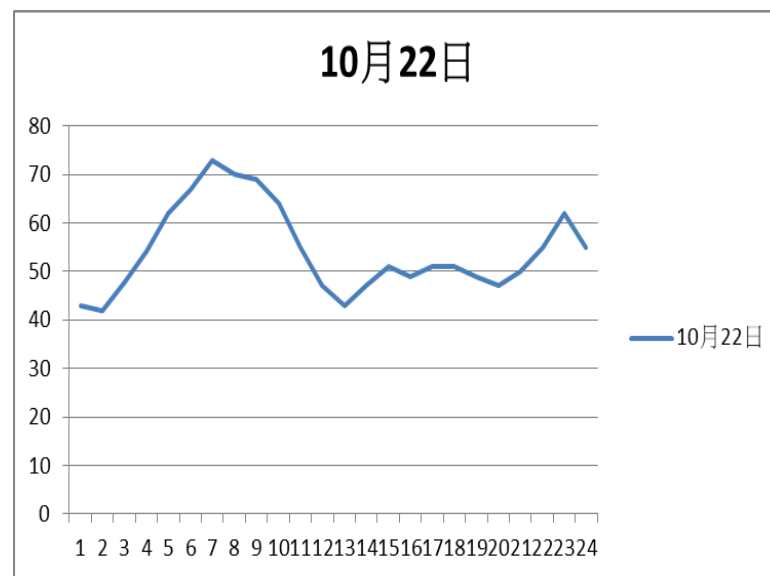
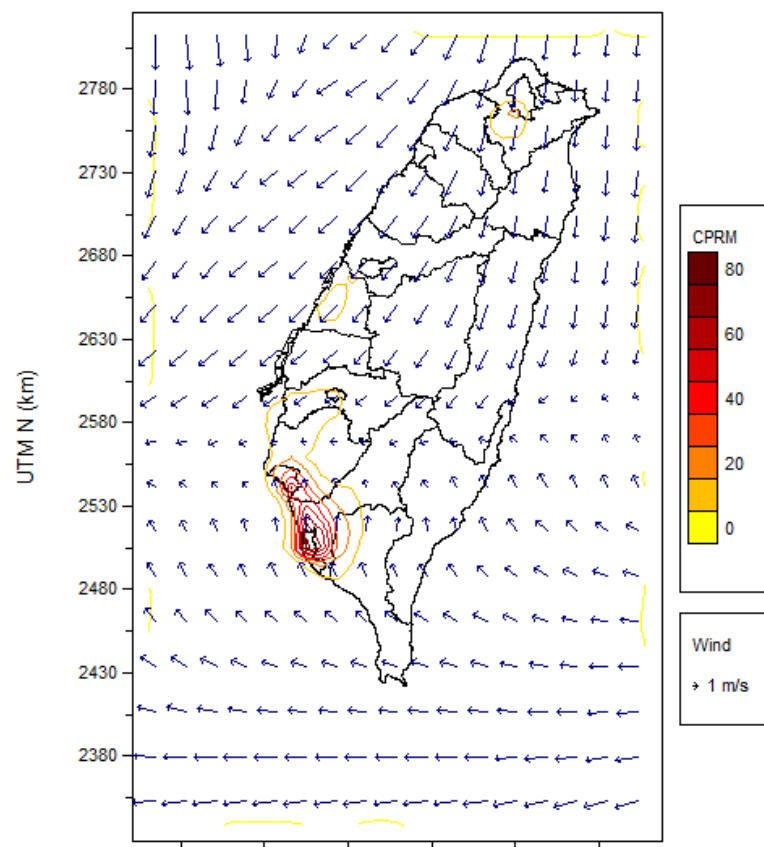
These results demonstrate that mountain height, together with the incoming flow strength and direction, plays a critical role in the formation and evolution of the leeside vortex.

合流

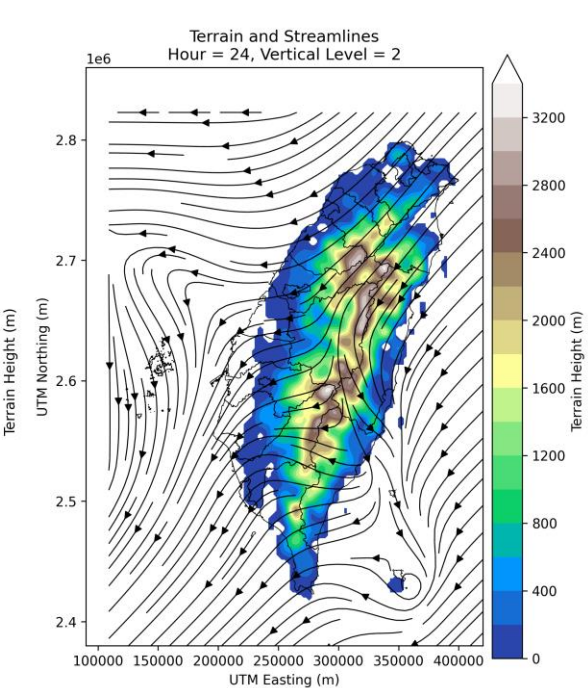
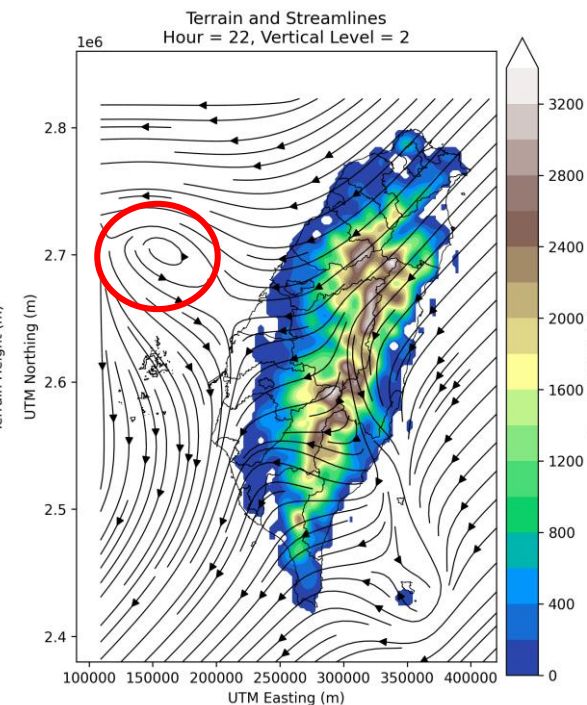
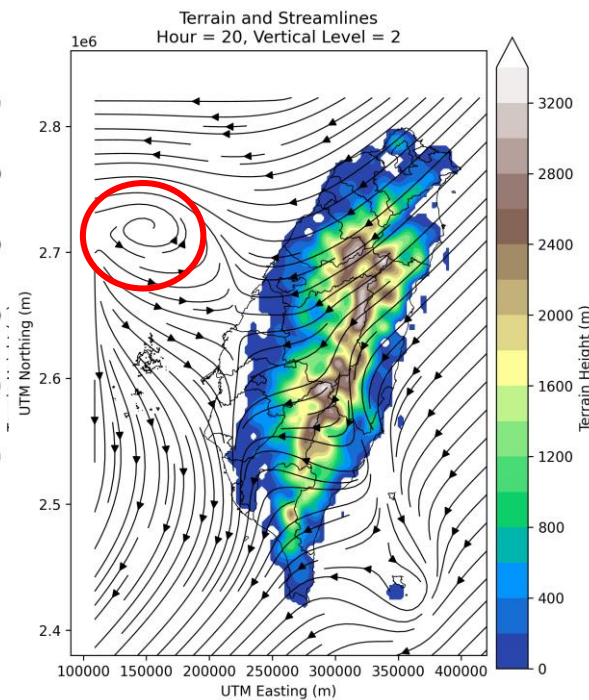
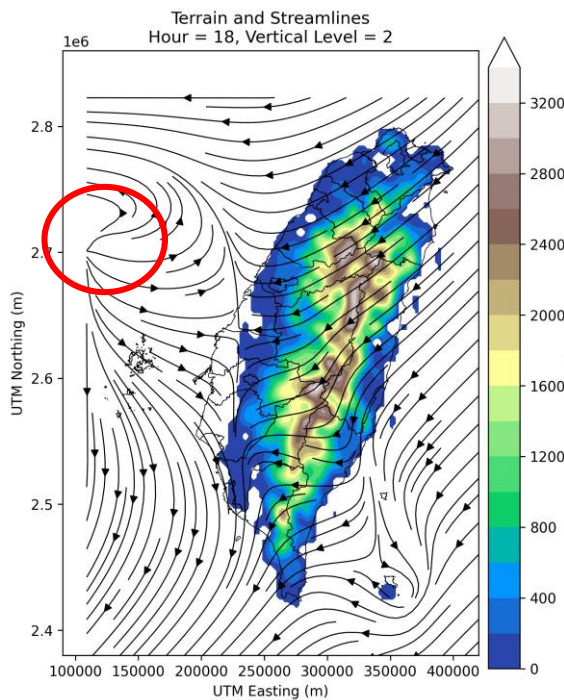


渦旋



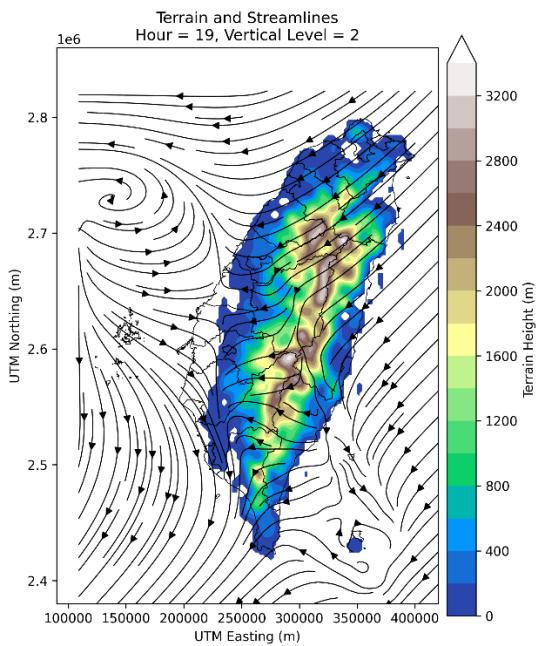


使用理想模式+CAMx，2018年10月22日1300時風場與PM10
濃度模擬並與左營觀測值比對

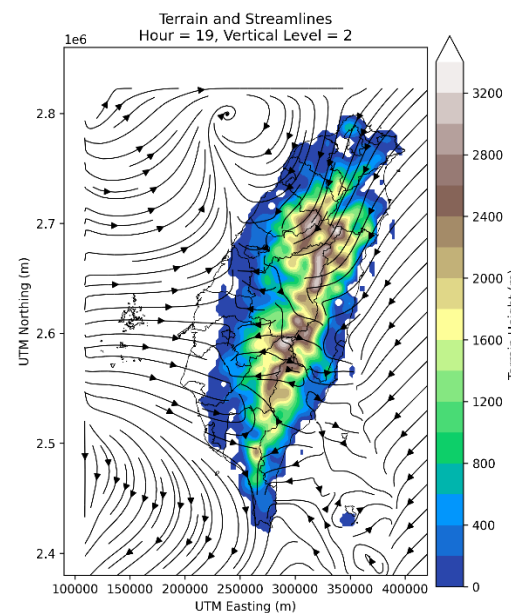


Layers	Height(m)
1	0.0
2	10.0
3	43.5
4	86.4
5	140.5
6	208.3
7	292.0
8	393.7
9	515.7
10	659.3
11	825.8
12	1015.6
13	1228.6
14	1464.4
15	1721.9
16	2000.0
17	2500.0
18	3250.0
19	4000.0
20	7000.0

CNR

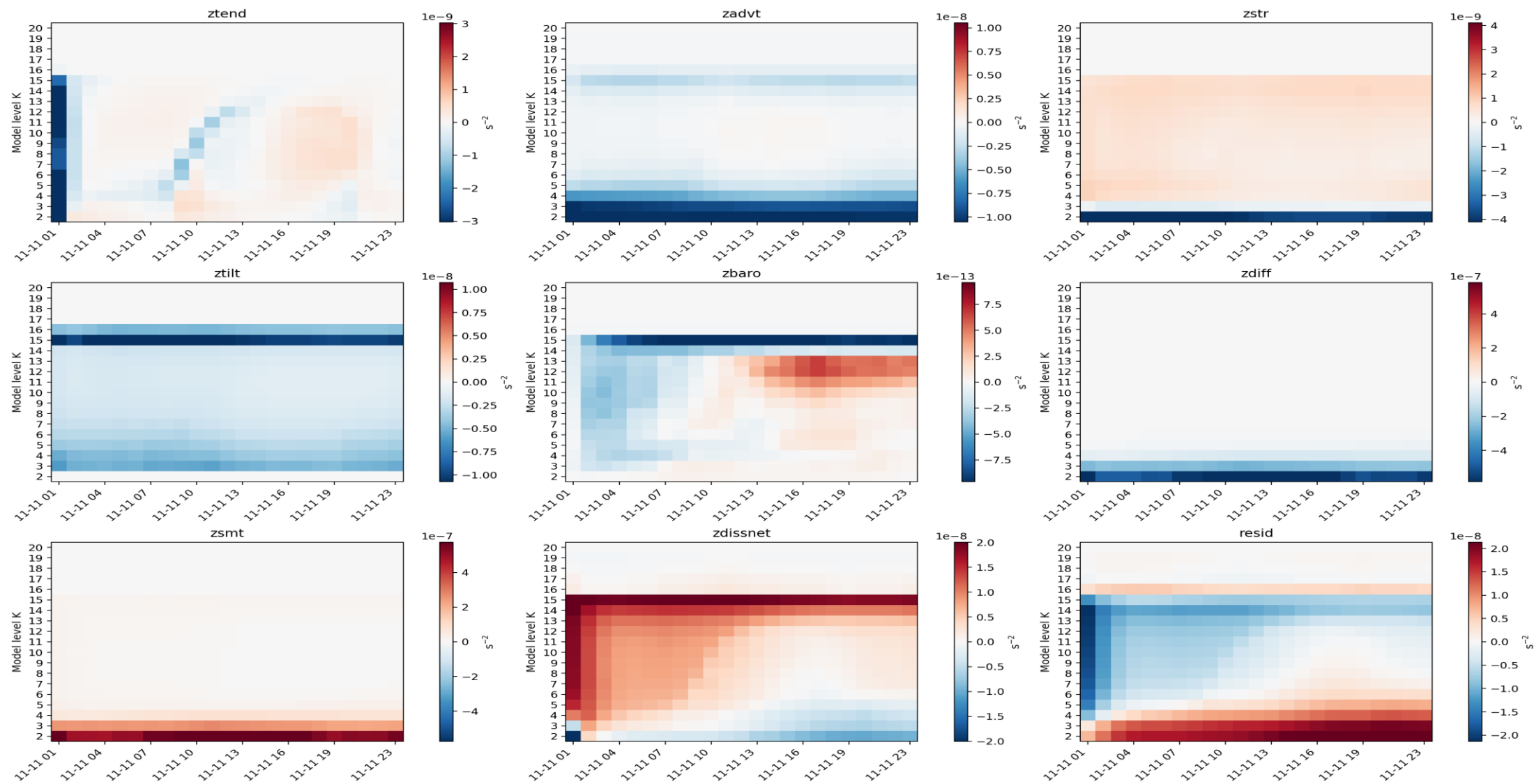


K=3之
垂直擴
散=0



timeterr.py

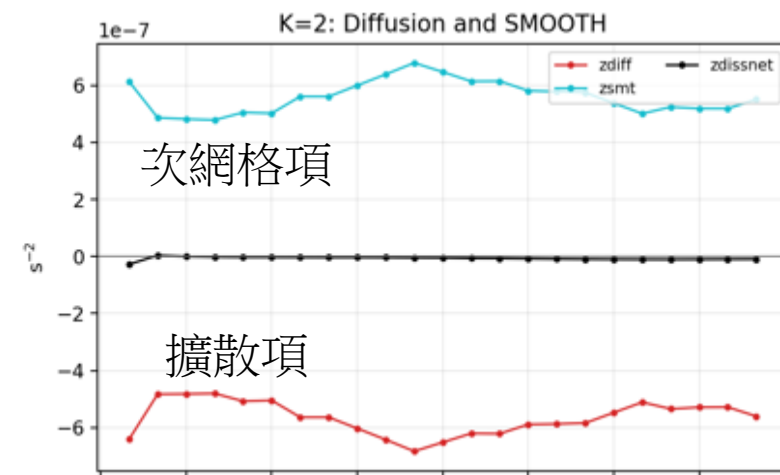
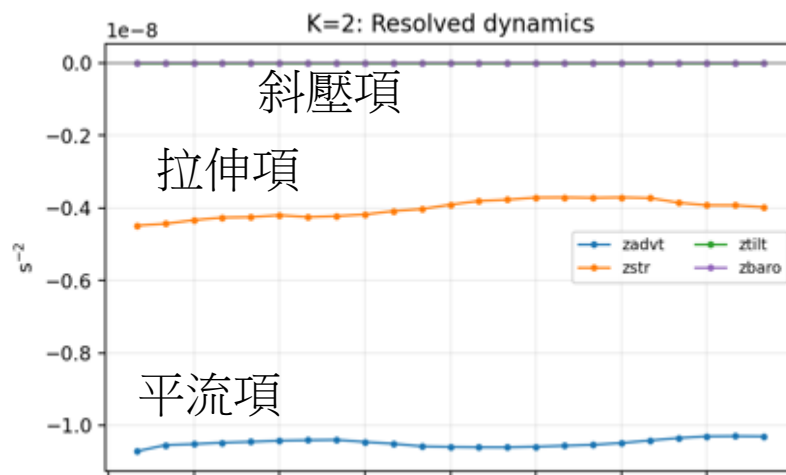
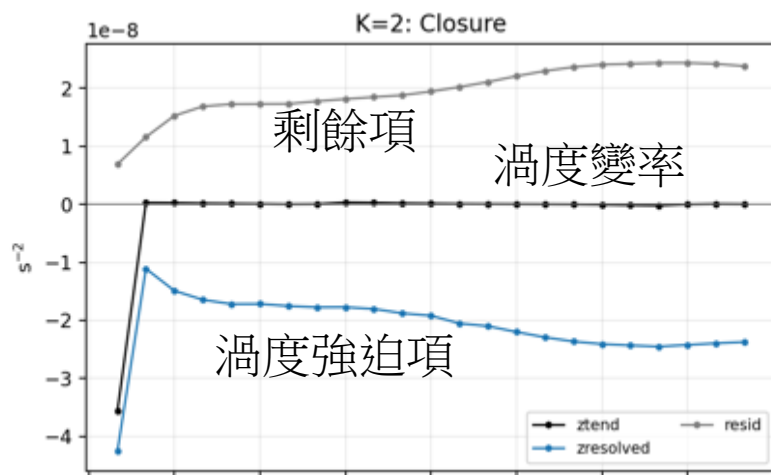
選該時間、分析範圍內「最負的5%格點」分析渦度衰減機制



低層渦度變化受到平流明顯控制；中低層弱輻合有助於增加正渦度；傾斜作用傾向減少區域平均正渦度；斜壓項可忽略；最低層的模式渦度受到強烈的次網格混合、地表摩擦或數值平滑調節。

模式低層 K=2的區域平均渦度收支閉合

$$Z_{\text{resolved}} = Z_{\text{ADV}} + Z_{\text{STR}} + Z_{\text{TILT}} + Z_{\text{BARO}} + Z_{\text{DIFF}} + Z_{\text{SMT}}$$



選該時間、分析範圍內「最強渦度格點

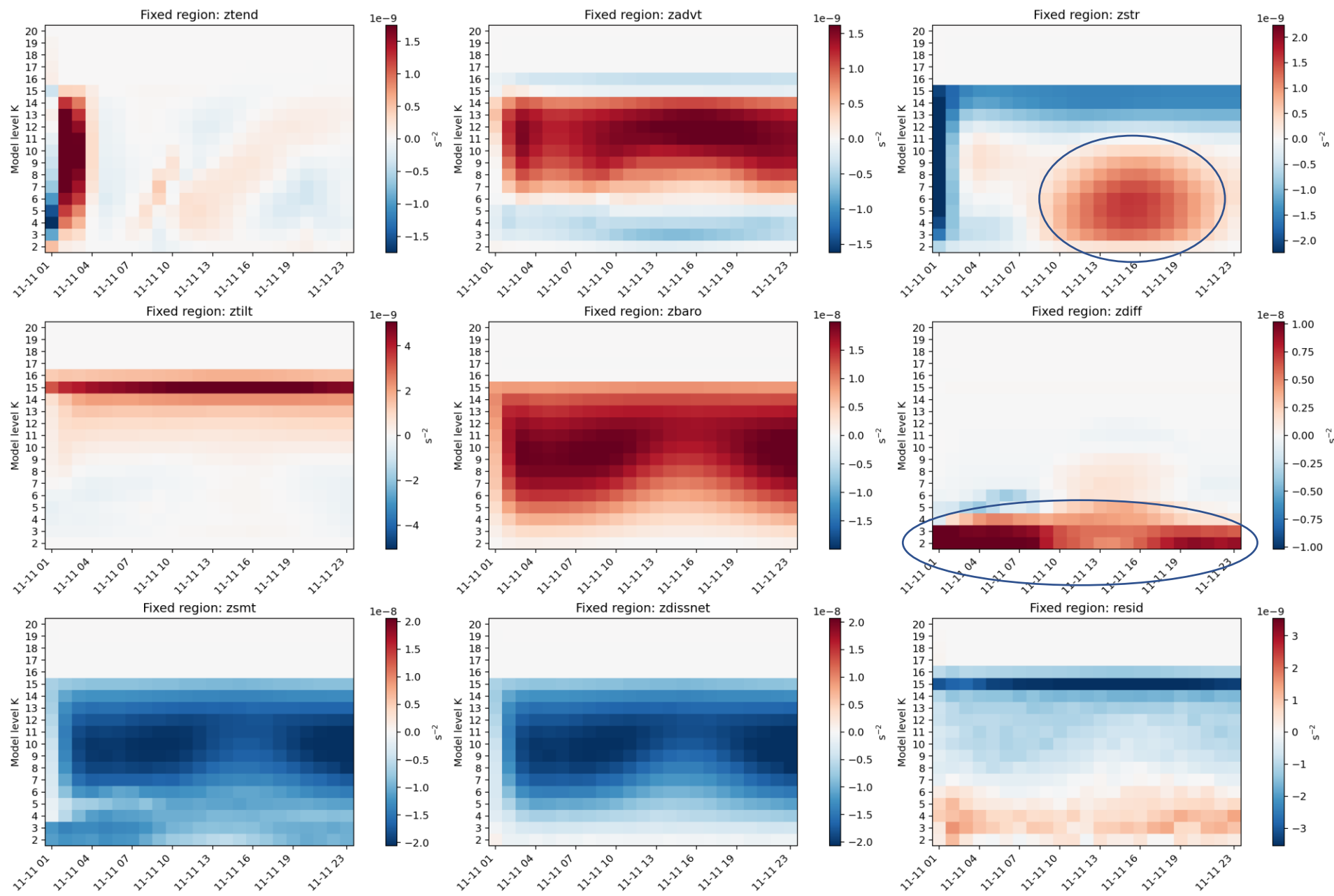
$I=10-30$ 、

$J=25-45$ 」分

析渦度演變機制

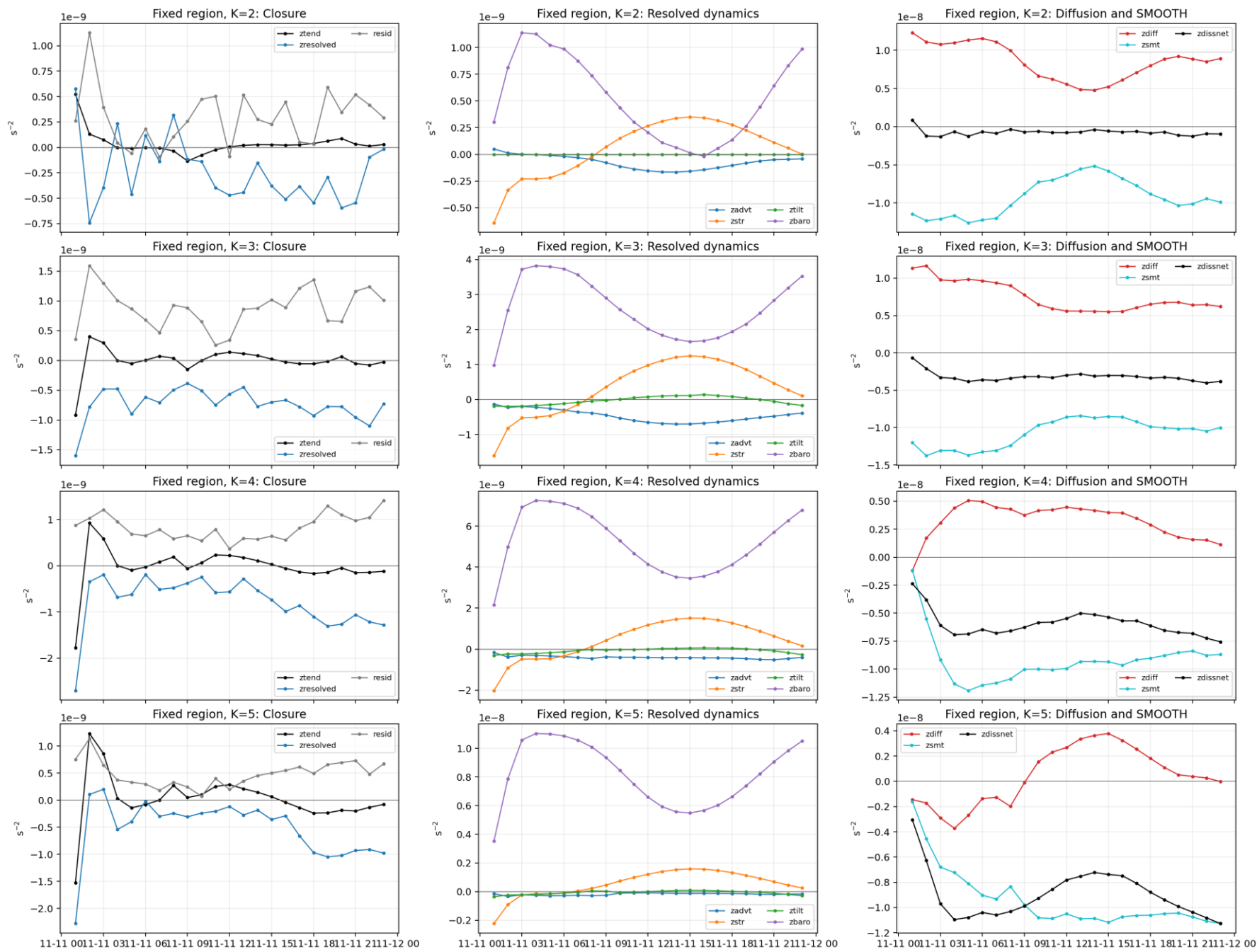
1. 正渦度主要在分析初期增強，後期趨勢較弱。
2. 平流項負貢獻
3. 後期低層拉伸亦有利於正渦度生成
4. 傾斜作用則主要位於渦旋上部。
5. 收支中最大的兩項為正斜壓項與負淨數值耗散項，兩者大致抵消

固定區各層的三欄收支圖

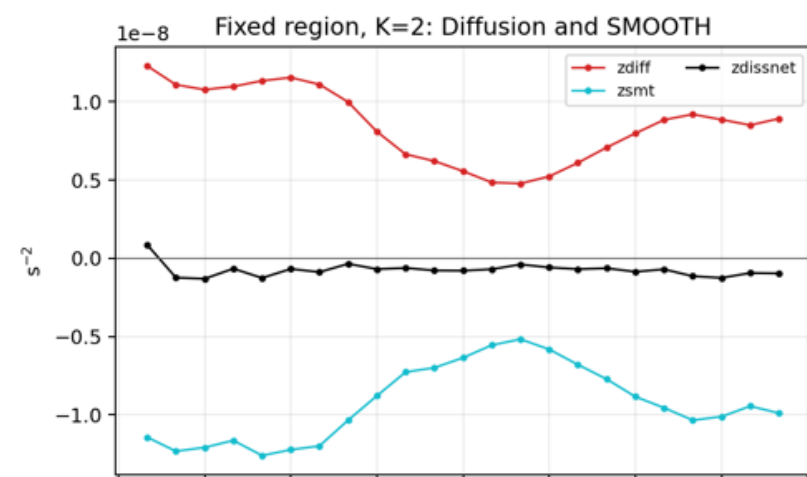
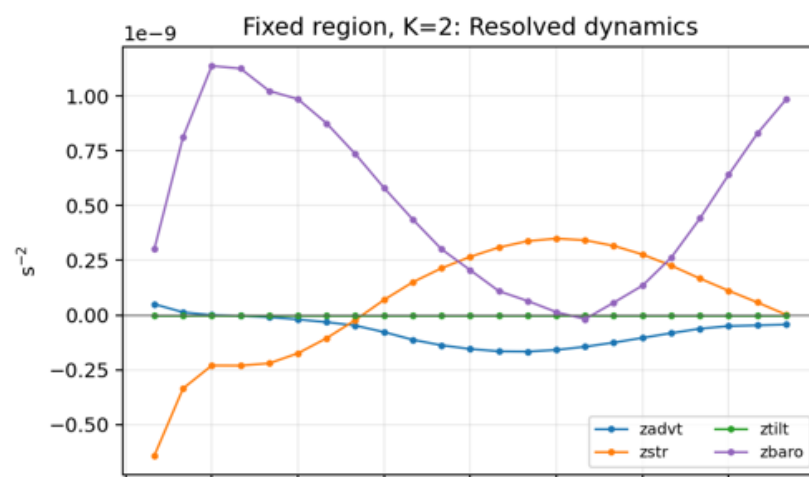
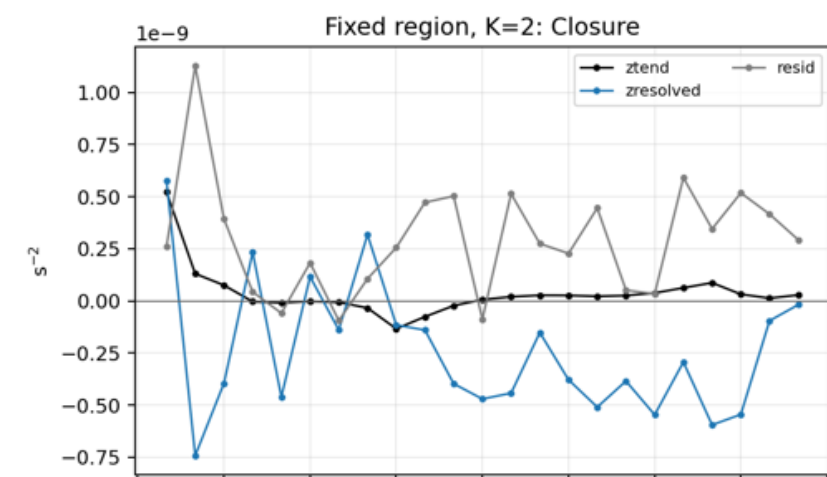


固定區的時間—高度渦度收支圖

固定背風區低層正渦度的實際趨勢整體較小。各高度均呈現正斜壓生成與負淨數值耗散之間的主要平衡，平流多對正渦度呈負貢獻，而拉伸項在午後低層轉為正。斜壓與平滑項的量級及垂直結構異常突出。



擴散項占重要貢獻



結論：

- 冷鋒通過台灣後，台灣西南部上空發展出一個地形引起的背風渦旋，並在嘉義地區產生了一條明顯的風切線。
 $PM_{2.5}$ 主要與背風渦旋、嘉義風切線以及地形引起的局部環流有關。
- WRF 敏感性試驗證實，背風渦旋的強度與演變受氣流與地形交互影響有關。
- 背風渦旋與地表摩擦與邊界層效應密切相關，拉伸項易有重要貢獻。