出國報告（出國類別：其他）

赴馬來西亞參加
「美國國家航空暨太空總署亞洲空品計畫 ASIA-AQ 2025 年研討會」

服務機關：環境部
姓名職稱：胡明輝副司長、陳彥君環境監測技術師
派赴國家：馬來西亞
出國期間：114 年 1 月 19 日至 114 年 1 月 23 日
報告日期：114 年 4 月 22 日

摘要

本部於113年2至3月藉由美國太空總署(NASA) ASIA-AQ飛航計畫中DC-8及GIII兩架科研飛機及國內外學者專家協作高屏 3D 空品實驗，掌握高屏地區影響空氣污染的氣象條件與大氣環流型態。「2025 年美國國家航空暨太空總署亞洲空品計畫ASIA-AQ研討會」期程為114年1月20日至1月24日，邀集參與AQIA-AQ 計畫的各國分享計畫成果透過與各國互相交流，從中獲得最新知識及訊息，增進及交流監測技術，加強國際合作。

本次年會共計5日，每日均由一個國家負責，其中1月22日為臺灣日，我國共計發表了16個口頭報告及13個海報，向他國分享我國監測分析成果，以及瞭解他國狀況，藉此次會議，透過國際合作的方式，與美方及東亞地區進行多邊交流，以及後續合作之可能性，亦提升我國國際能見度。

目錄

壹、 目的及背景說明

本部於 113 年 2 至 3 月藉由美國太空總署(NASA) ASIA-AQ 飛航計畫中 DC-8 及 GIII 兩架科研飛機及國內外學者專家協作高屏 3D 空品實驗，掌握高屏地區影響空氣污染的氣象條件與大氣環流型態，特別是 200 至 800 公尺垂直高度上污染物的變化，以及細懸浮微粒（$PM_{2.5}$）和臭氧（O_3）和臭氧及其前驅物與高潛勢化學物質等之監測成果。

「2025 年美國國家航空暨太空總署亞洲空品計畫 ASIA-AQ 研討會」期程為 114 年 1 月 20 日至 1 月 24 日，邀集參與 AQIA-AQ 計畫的各國分享計畫成果透過與各國互相交流，從中獲得最新知識及訊息，增進及交流監測技術，加強國際合作。

貳、 會議行程說明

本次會議地點為馬來西亞的馬來西亞國立大學，會議總計 5 日，1 月 20 日主要由美國太空總署科學家們說明 ASIA-AQ 計畫總覽，以及相關分析結果，1 月 21 日為泰國日，1 月 22 日為臺灣日，1 月 23 日為菲律賓日，1 月 24 日為韓國日，每日詳細報告議題如附件。在 1 月 22 日，我國共計發表了 16 個口頭報告及 13 個海報，向他國分享我國監測分析成果，以及瞭解他國狀況（會議中有很多對生質燃燒的探討，部分生質燃燒可能影響我國空氣品質），藉此次會議，透過國際合作的方式，與美方及東亞地區進行多邊交流，以及後續合作之可能性，亦提升我國國際能見度。

參、 心得與建議

一、 心得：

(一) ASIA-AQ(Airborne and Satellite Investigation of Asian Air Quality)是一項國際合作的研究計畫，可以現有地面監測系統協助衛星觀測校驗，以及與空品模式的整合，提升亞洲地區空氣品質監測能力。在計畫中，美國 NASA(National Aeronautics and Space Administration)提供了科研飛機，

藉由短期的監測，提供多維度的監測數據，對於衛星及空品模式準確度有很大的改善。

(二) ASIA-AQ 計畫之前，部分國家已經有參與過 KORUS-AQ、CAMP2EX 等計畫，因此 ASIA-AQ 計畫的監測資料，可與過去其他計畫的資料進行比對，或進行趨勢分析。我國在 113 年參與 ASIA-AQ 計畫，搭配自辦的高屏 3D 監測計畫，完成 4 次密集觀測、垂直觀測與 NASA 飛航觀測，在國內既有的 2D 監測基礎上，加上了 3D 環境監測，解析局地環流與多項空氣污染物及地形的三維時空分布特徵，實屬難得。

(三) 本次 ASIA-AQ 各國合作單位分別為菲律賓的環境與自然資源部 (Department of Environment and Natural Resources ,DENR)、菲律賓太空總署(Philippine Space Agency, PhilSA)、馬尼拉天文台；韓國的國家環境研究院 (National Institute of Environmental Research, NIER)、氣象廳(Korea Meteorological Administration, KMA)。；泰國的地理資訊和太空技術發展中心(Geo-Informatics and Space Technology Development Agency, GISTDA)、PCD，以及我國環境部、中央研究院、許多大學及研究機構。

(四) 本次 ASIA-AQ 2025 年研討會，我國共發表了 16 個口頭報告及 13 個海報，向他國分享我國監測分析成果，以及瞭解他國狀況（會議中有很多對生質燃燒的探討，部分生質燃燒可能影響我國空氣品質），藉此次會議，透過國際合作的方式，與美方及東亞地區進行多邊交流，以及後續合作之可能性，亦提升我國國際能見度。

(五) 各國對於空氣污染物監測項目，多著重在懸浮微粒及氣膠的分析，相對來說，對於揮發性有機物的監測相較之下較少。反觀我國對於揮發性有機物之監測相對成熟（自民國 92 起即

設有光化學評估監測站），累積多年監測經驗及數據。而ASIA-AQ 計畫中，NASA DC-8 科研飛機上，除了有傳統使用採樣桶收集揮發性有機物，再回實驗室分析的方法外，亦採用高解析度飛行時間 TOGA 系統，可提供更短分析頻率的監測數據。

(六) NASA 的科研飛機 DC-8 是大氣成分測量飛機，總飛行 161 小時，包含 26 臺儀器測量氣象及氣膠相關參數，包含氣狀的臭氧、一氧化碳、二氧化氮、一氧化氮、二氧化硫、甲醛、氨、溫室氣體(CO_2、CH_4、N_2O)、總氮氧化物(NO_Y)；氣膠量測的 $PM_{2.5}$ 濃度與成分（有機氣膠、硫酸鹽、硝酸鹽、黑碳等）、微粒數量、粒徑分布、光學性質及雲凝結核(CCN)；其他還有太陽輻射及高解析度氣象參數等。DC-8 的飛行方式包含低空飛行（1 公里以下）-可直接量測地面污染物來源及濃度，垂直剖面飛行（1~12 公里）-分析污染物高度變化，驗證衛星數據，區域掃描-了解污染源來源與分佈，以及配合衛星通過時間，與衛星觀測結果進行比對。DC-8 的數據可補充地面監測的盲點，提供更詳細的監測數據，並與 GEMS 等衛星進行比對驗證，並改善 $PM_{2.5}$ 及臭氧空品模式。

(七) 氣象是導致空氣品質不良及能見度降低的關鍵因素，而本次計畫的採樣點其實位於不同的氣候帶中，例如菲律賓位於熱帶地區，採樣期間屬於旱季，盛行東北季風，可能影響污染物濃度變化的因素包含東北季風強度及局部天氣特徵，而當地的燃燒行為也會影響空氣品質，但限制在於缺乏地面監測資料。而臺灣位於亞熱帶地區採樣時間為冬季，韓國則是中緯度國家，採樣時間為冬季。

(八) 從 AOD 的資料可以看到我國在個案中有地表吹東風，而高空吹偏西風的狀況，與我國團隊使用風光達進行盛行風向垂直

剖面解析之發現相似，從地面至3000公尺高空，有不同風帶之分佈。此外我國超級測站在地面監測發現 PM2.5 有機物占比較高（約40%）情形，亦與NASA於我國飛航監測結果發現有機物有高占比情形相似。

二、 建議事項

（九）衛星觀測溫室氣體及大氣污染物是我國相對不足之處，目前我國引用之衛星資料多為歐洲太空總署TROPOMI及韓國GEMS衛星等，而韓國研究團隊皆使用該國之GEMS衛星資料做遙測比對，與傳統的LEO衛星相比，GEMS衛星可以每小時的頻率進行觀測，提供更細緻的空品監測視角，並與地面監測站相互比對。衛星觀測具空間分布及範圍寬廣的週期性觀測優點，配合先進遙測技術之整合開發，對於我國大氣與地表環境近即時之時空分布可有效且準確地掌握。爰此，本部於 113 年 11 月 26 日與國家太空中心簽署「衛星應用在環境監測與溫室氣體觀測交流合作協議」，並於113年10月28日提出「因應氣候變遷淨零碳排－整合衛星與次世代環境大氣及溫室氣體監測評估」中長程計畫，期望發展應用衛星觀測溫室氣體與大氣環境空氣品質，建構臺灣衛星溫室氣體觀測星系。

（十）NASA 科研飛機 DC-8 和 GIII 雖可提供垂直及高層監測資料，但因為採樣的時間比較短（僅特定幾日），自然有其限制，例如無法在我們想要的監測時間或特定污染特性時進行監測，而在各國比較間也有其限制，包含不同的緯度、天氣型態等放在一起比較可能不是很合適（例如在不同緯度、溫度下，異戊二烯濃度會有很大的差異）。我國在ASIA-AQ期間，以無人機採樣以及地面採樣及連續監測，可補其不足，並提供很多的研究資訊。我國本次在 ASIA-AQ 期間，於高雄楠梓及鳳山進行 $PM_{2.5}$、$PM_{1.0}$ 及超細懸浮微粒（UFP）之監測分析，包含

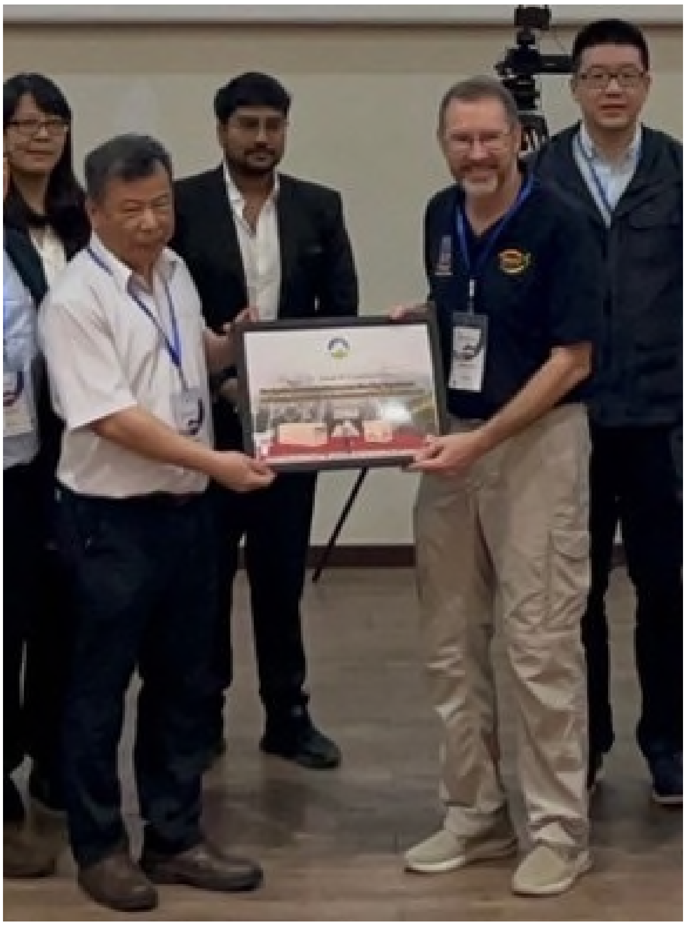
質量濃度、數量濃度及粒徑分布等物理特性，以及化學成分分析，提供相當多監測資訊。本部於「因應氣候變遷淨零碳排－整合衛星與次世代環境大氣及溫室氣體監測評估」計畫中，提出建置次世代大氣環境空氣品質監測技術之規劃，可提供高時間解析度之即時監測資料，提供更全面的環境監測及源解析能力。

(十一) ASIA-AQ 計畫及本部高屏監測計畫，取得了相當豐富的監測數據，提供高屏空氣污染成因及解析，並可作為防制策略訂定及評估的科學資訊。雖後續無飛航觀測的支援，此計畫模式仍可複製到我國其他區域使用，目前已規劃 114 年執行雲嘉南至高屏地區之監測計畫，期望可繼續深入瞭解各區域污染特性。

附錄 1、出國期間照片

圖一、與會人員大合照

圖二、我國與會人員與 NASA James Crawford 合照



圖三、胡明輝副司長致贈James Crawford感謝狀

圖四、林能暉教授報告我國高屏監測計畫概述

圖五、林能暉教授與楊禮豪教授主持第三日(Taiwan Day)討論會議

圖六、各國人員積極分享及參與討論

附錄 2、會議議程表

ASIA-AQ 2025

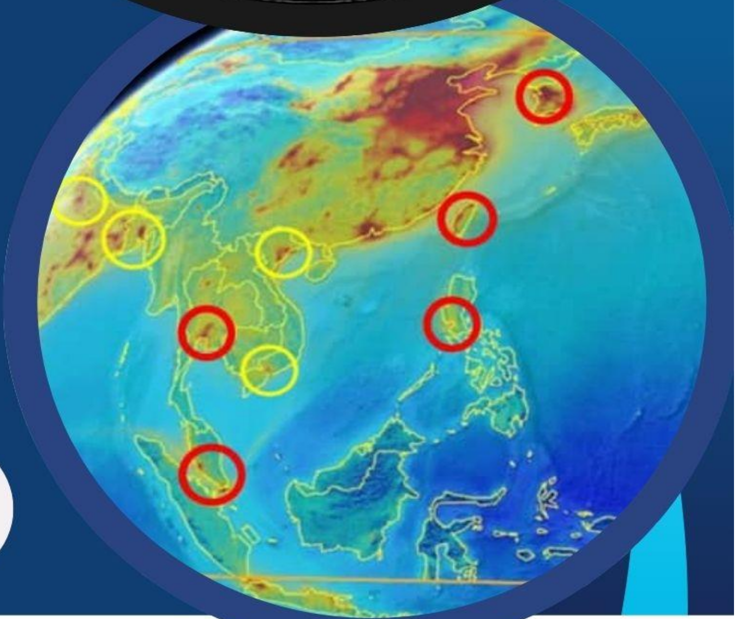
Science Team Meeting

Airborne and Satellite Investigation of Asian Air Quality

ASIA-AQ

NIER • DENR • UKM • GISTDA • MOENV • NASA

- The Airborne and Satellite Investigation of Asian Air Quality (ASIA-AQ) is an international cooperative field study designed to address local air quality challenges.
- Specifically, ASIA-AQ will contribute to improving the integration of satellite observations with existing air quality ground monitoring and modelling efforts across Asia.



20-24 JANUARY 2025

UNIVERSITI KEBANGSAAN MALAYSIA, BANGI SELANGOR, MALAYSIA

For further information, please visit:
https://ukm-atmosphere.com/

Organized by:

NASA · Universiti Kebangsaan Malaysia (The National University of Malaysia) · Naratif Baharu UKM Universiti Watan Kita · MAAQR · Malaysia Convention & Exhibition Bureau

Supporting organization:

Ministry of Environment National Institute of Environmental Human Resources Development · 環境部 Ministry of Environment · GISTDA

Oral Presentation

Day 1: 20 January 2025

8:00 – 8:30	**Registration**
8:30 – 9:00	**Welcoming Remarks** Mohd Talib Latif (UKM), Barry Lefer (NASA), Jung-Min Park (NIER), Pakorn Apaphant (GISTDA), George Lin (NCU), Chadbert Aquino (DENR)
Session 1.1	**Session Chair: Jack Dibb**
9:00 – 9:15	ASIA-AQ Overview ***Jim Crawford***
9:15 – 9:30	Meteorology Influencing Local and Regional Air Quality during ASIA-AQ ***David Peterson***
9:30 – 9:45	Intercomparison of Satellite Remote Sensing Results with Airborne and Ground-based Observations during the ASIA-AQ ***Jhoon Kim***
9:45 – 10:00	*GCAS Observation Overview from ASIA-AQ* ***Laura Judd***
10:00 – 10:30	**Tea Break**
Session 1.2	**Session Chair: Louisa Emmons**
10:30 – 10:45	HSRL-2 Measurements during ASIA-AQ and Comparisons to $PM_{2.5}$ ***Taylor Shingler***
10:45 – 11:00	VOCs Spatial Distribution and Characterization during ASIA-AQ. Preliminary Findings ***Simone Meinardi***
11:00 – 11:15	Preliminary Analysis of Local and Transported Pollution into Philippines, Taiwan, and South Korea ***Rebecca Hornbrook***
11:15 – 11:30	Major VOC Contributors to OH Reactivity in Major Centers during ASIA-AQ ***Eric Apel***
11:30 – 11:45	Using Airborne In-Situ Greenhouse Gas Enhancement Ratios to Characterize Regional Combustion Source Signatures during ASIA-AQ ***Jason Miech***

11:45 – 12:00	Observations of PANs in South Korea and the Philippines ***Greg Huey***
12:00 – 13:30	**Lunch Break**
Session 1.3	**Session Chair: Laura Judd**
13:30 – 13:45	Importance of HONO as a Radical Source over South Korea and Thailand ***Katherine Paredero***
13:45 – 14:00	Evaluating Oxidation Capacity using the Observational Constraints ***Saewung Kim***
14:00 – 14:15	Overview of LARGE Aerosols Measurements During ASIA-AQ ***Richard Moore***
14:15 – 14:30	Aircraft Measurement of CCN Concentrations during the ASIA-AQ Campaign ***Seong Soo Yum***
14:30 – 14:45	Probing the Thermodynamics of Submicron Aqueous Aerosols over A Wide Range of Conditions: Insights from the NASA ASIA-AQ Aircraft Mission ***Pedro Campuzano Jost***
14:45 – 15:00	Airborne Measurement of $PM_{2.5}$ Composition on Board the DC-8 during the ASIA-AQ Campaign ***Haiyan Jin***
15:00 – 15:30	**Tea Break**
Season 1.4	**Session Chair: Hiroshi Tanimoto**
15:30 – 15:45	Atmospheric Ammonia Measured in ASIA-AQ ***Yunseo Choi***
15:45 – 16:00	Individual Particle Measurements of Aerosols using Transmission Electron Microscopy ***Kouji Adachi***
16:00 – 16:15	Evaluation of Emissions Inventories in MUSICAv0 ***Louisa Emmons***
16:15 – 16:30	Model, Satellite, and Airborne NO_2 Comparisons across Southeast Asia: A Case Study during ASIA-AQ ***Julianna Christopoulos***
16:30 – 16:45	Source Attribution to Surface Ozone in Asia during ASIA-AQ: NO_x tagging in MUSICAv0 ***Jun Zhang***

16:45 – 17:00	Analysis of Ozone and Nitrate Formations in Asian Mega-cities during the ASIA-AQ ***Changmin Cho***
17:00 – 17:15	Sources of Formaldehyde and its Role in Radical Formation during ASIA-AQ ***Abby Sebol***
17:15 – 17:30	Regional Variations in Glyoxal Enhancement and Their Implications from the Airborne Measurements of ASIA-AQ and SENEX Campaign ***Heejoo Kang***
17:30	Adjourn

Day 2: 21 January 2025

Session 2.1	**Session Chair: Kandasri Limpakom**
8:30 – 8:45	Air Pollution and Policy Development in Thailand ***Ittipol Pawarmart***
8:45 – 9:00	Evaluating the Correlation Between DC-8 Aircraft Measurements and GEMS Satellite Observations for NO_2 Monitoring in Support of ASIA-AQ (Thailand) ***GISTDA***
9:00 – 9:15	Assessment of Air Pollutant Emission Sources Contributing to $PM_{2.5}$ formation in Bangkok Metropolitan Region (BMR), Thailand ***Savitri Garivait***
9:15 – 9:30	An Enhanced Urban Emission Inventory for Greater Bangkok with Anthropogenic Heat Emissions and Urban Geometry in Support of ASIA-AQ (Thailand) ***Kasemsan Manomaiphiboon***
9:30 – 9:45	Transboundary Nature of Smoke Haze and Health Impacts in Southeast Asia ***Greg Carmichael***
9:45 – 10:00	Ozone Formation in Thailand ***Nantaporn Noosai***
10:00 – 10:30	**Tea Break**
Session 2.2	**Session Chair: Budsaba Oamkasem**
10:30 – 10:45	Predicting Burned Area in Thailand during March 2024 ***Nattamon (Jeep) Maneenoi***
10:45 – 11:00	Aerosol Properties Along the Urban-Biomass Burning Continuum in Thailand ***Sayantee Roy***
11:00 – 11:15	Organic Aerosol Mass Fraction in the Thai Summer Smog from ASIA-AQ: Implications on the Challenges of Their Source Apportionment using HR-TOF-AMS ***Sarunpron Khruengsai***

11:15 – 11:30	Aerosol Optical Properties during the Asia-AQ Campaign in Thailand ***Itsara Masiri***
11:30 – 11:45	Biomass Burning Emissions in Thailand Measured by PTR-MS ***Wojciech Wojnowski***
11:45-12:00	The Impact of Biomass Burning on Air Quality ***Taehyoung Lee***
12:00 – 13:30	**Lunch Break**
Session 2.3	**Session Chair: Viphada Boonlerd**
13:30 – 13:45	Characteristics of O_3 and Fine Aerosol Enhancement in Northern Thailand during the ASIA-AQ Campaign: Insights from Comprehensive Ground Observations ***Junsu Gil***
13:45 – 14:00	Air Pollution Situation in the Eastern Economic Corridor Area: Data Collected from Aircraft Measurements under the Asia-AQ Project ***Narissara Thongboonchoo***
14:00 – 14:15	ASIA-AQ Implication to $PM_{2.5}$ and Climate Interactions for Direct/Indirect Effects and Feedback ***Vanisa Surapipith***
14:15 – 14:30	Investigating SOA Distribution and Precursors using ASIA-AQ Campaign Data and WRF-Chem Simulations in Thailand ***Sherin Hassan Bran***
14:30 – 14:45	Changes in $PM_{2.5}$ Spatial Distribution over Thailand during the ASIA-AQ Measurement Campaign ***Ronald Macatangay***
14:45 – 15:00	Source Appointment and Health Risk Assessment of $PM_{2.5}$-Bound Heavy Metals in Southern Thailand: A Positive Matrix Factorization and Artificial Neural Networks Approach ***Siwatt Pongpiachan***
15:00 – 16:30	**Tea Break and Poster Session** (Emphasis on Odd Numbered Posters 1-41)
16:30 – 18:00	Priority findings and remaining gaps for Thailand's RSSR ***Discussion*** ***Lead: Narisara Thongboonchoo and Greg Carmichael***
18:00	Adjourn

Day 3: 22 January 2025

Session 3.1	**Session Chair: Ta-Chih Hsiao**
8:30 – 8:45	Overview of the Kao-Ping Experiment (KPEx) in Southern Taiwan during ASIA-AQ ***Neng-Huei (George) Lin***
8:45 – 9:00	Terrain Effect on Vertical Atmospheric Structure in Taiwan during KPEx ***Hsin-Chih Lai***
9:00 – 9:15	High-Resolution Atmospheric Profiling via UAV: Key Findings from the ASIA-AQ Taiwan KPEx Field Campaign ***Sheng-Hsiang Wang***
9:15 – 9:30	Numerical Study Boundary Layer Circulations Impact on Air Pollutants Formation and Transportation during KPEx IOP#3 over Southwestern Taiwan ***Chuan-Yao Lin***
9:30 – 9:45	Simulating the Long-range Transport of Pollutants in CMAQ (v5.3.3) during the 2024 KPEx Experiment ***Steven Soon-Kai Kong***
9:45 – 10:00	Characteristics of VOCs based on DC-8 and Ground-Level Measurements during 2024 ASIA-AQ IOPs in Taiwan ***Chang-Feng Ou-Yang***
10:00 – 10:30	**Tea Break**
Session 3.2	**Session Chair: Kai Hsien Chi**
10:30 – 10:45	Comparison of Ground-based MPL and ASIA-AQ G-III Airborne HRSL Aerosol Profiles over Taiwan during the KPEx ***Yueh-Chen Wang***
10:45 – 11:00	Spatiotemporal Variations in Chemical Composition of Atmospheric Aerosols in the 2024 Kao-Ping Experiment Campaign (KPEx) in Southern Taiwan ***Ying I. Tsai***
11:00 – 11:15	The Properties and Dynamics of Aerosols: Insights from (dual) Supersites Measurements during KPEx and ASIA-AQ IOPs in Taiwan ***Ta-Chih Hsiao***
11:15 – 11:30	Chemical Mass Closure and Sources of Hourly $PM_{2.5}$ in Southern Taiwan during the Kao-Ping Experiment (KPEx) ***Li-Hao Young***
11:30 – 11:45	Partitioning of Photochemical Pathways to the Production of Particulate Nitrates in Southern Taiwan during the KPEx/ASIA-AQ Campaign ***Mao-Chang Liang***

11:45 – 12:00	Isotopic Evidence of Nitrate Aerosol Formation and Source Dynamics in the Atmosphere of Southern Taiwan ***Prateek Sharma***
12:00 – 13:30	**Lunch Break**
Session 3.3	**Session Chair: Sheng-Hsiang Wang**
13:30 – 13:45	Atmospheric PAHs, Source Attributed Profile and Oxidative Potential in $PM_{2.5}$ during Daytime and Nighttime in Kao-Ping Experiment (KPEx) ***Kai Hsien Chi***
13:45 – 14:00	Spatial Distribution Characteristics of Atmospheric Persistent Organic Pollutants during 2024 Kao-Ping Experiment ***Lin-Chi Wang***
14:00 – 14:15	Distribution of Atmospheric Mercury during 2024 KPEx and Introduction to the Aisa Pacific Mercury Monitoring Network (APMMN) ***Guey-Rong Sheu***
14:15 – 14:30	The Characteristics of HAPs during Events and Non-events in Different Asian Cities ***Shih Yu Pan***
14:30 – 15:30	**Tea Break and Poster Session** (Emphasis on Even Numbered Posters 2-30)
15:30 – 17:00	Priority findings and remaining gaps for Taiwan's RSSR ***Discussion*** ***Lead: Neng-Huei (George) Lin and Li-Hao Young***
17:00	Adjourn
19:30-22.30	**ASIA-AQ 2025 Science Team Meeting Dinner** **Tenera Hotel, Bangi**

Day 4: 23 January 2025

Session 4.1	**Session Chair: Melliza Cruz**
9:00 – 9:15	Air Quality Monitoring during NASA ASIA-AQ (Philippines) ***Chadbert Nikko Aquino***
9:15 – 9:30	Insights on Potential Sources based on Spatial Distribution of PM Components ***Maria Obiminda Cambaliza***
9:30 – 9:45	Characterization of Nitrogen Dioxide and Ozone over Metro Manila during ASIA-AQ ***Mary Angelique Demetillo***
9:45 – 10:00	Airmass Source Influences from Trace Gas Ratio Enhancements over the Philippines during CAMP2Ex and ASIA-AQ ***Joshua DiGangi***

10:00 –10:15	Modeling of A Degassing Volcanic Plume using a High-Resolution Regional Model: Insights from Evaluating Against Satellite Retrievals and Airborne In-Situ Observations from the ASIA-AQ Field Campaign ***Manas Mohanty***
10:15 –10:30	$PM_{2.5}$ Composition, Sources, Chemistry and Volatility over Greater Manila: Insights from the ASIA-AQ Campaign ***Guy Symonds***
10:30 –10:45	Urban Surface Properties and Their Potential Connections with Urban AQ ***Wenfu Tang***
10:45 –11:15	**Tea Break**
11:15 –12:30	Priority Findings and Remaining Gaps for Philippines' RSSR ***Discussion*** ***Lead: Maria Obiminda Cambaliza and James Simpas***
12:30-14:00	**Lunch Break**
Session 4.2	**Session Chair: Meehye Lee**
14:00 –14:15	Characterization of Formation Mechanisms for Particulate Nitrosamines and Nitramines in Urban and Background Atmospheres ***Na Rae Choi***
14:15 - 14:30	Estimation of Emission Rates from Point/Area Sources and Validation of NO_2 Vertical Profile using Airborne Measurements ***Yongjoo Choi***
14:30 - 14:45	Analysis of GHG Observed from Airborne, Research Vessel, Surface GAW Site and Tall Tower during ASIA-AQ Campaign over Korea ***Sunran Lee***
14:45 –15:00	Comparing Morning-Afternoon Difference of AOD using LEO and GEO Satellite Measurements in East Asia ***Ja-Ho Koo***
15:00 - 17:00	**Tea Break and Poster Session** (Emphasis on Even Numbered Posters 32-40 and All Posters from 42-62)
17:00	Adjourn

Day 5: 24 January 2025

Session 5.1	**Session Chair: Limseok Chang**
8:30 – 8:45	SIJAQ Policy Implication ***Limseok Chang***
8:45 – 9:00	A Brief Update of the Korean RSSR for the ASIA-AQ Campaign ***Rokjin Park***
9:00 – 9:15	Nocturnal Boundary Layer Height Uncertainty in Particulate Matter Simulations ***Cheol-Hee Kim***
9:15 – 9:30	Wintertime Formation Pathways of Secondary Inorganic Aerosols Driving High $PM_{2.5}$ Episodes in the Seoul Metropolitan Areas ***Meehye Lee***
9:30 – 9:45	Characteristics of High $PM_{2.5}$ Nitrate Events in Seoul during the Winter ASIA-AQ Campaign ***Hyunmin Lee***
9:45 – 10:00	Phases and Morphologies of $PM_{2.5}$ in South Korea During ASIA-AQ Campaign ***Mijung Song***
10:00 –10:30	**Tea Break**
Session 5.2	**Session Chair: Gangwoong Lee**
10:30 –10:45	Characteristics of Emission and Transport of VOCs in Seoul during the ASIA-AQ Campaign ***Joo-Ae Kim***
10:45 –11:00	Variations in Physicochemical Properties of Refractory Black Carbon Particles Indicating Pollution Processes in Seoul, South Korea ***Changdong Yun***
11:00 –11:15	Wintertime Submicron Aerosol Formation and Chemical Composition during the ASIA-AQ ***Taehyoung Lee***
11:15 –11:30	Assessment of Spatial-Temporal and Emission Distribution of NH_3 using Airborne Measurements over South Korea ***Jeonghwan Kim***
11:30 –11:45	ASIA -AQ version 3 Emissions: Emissions Inventory to Support the NASA/NIER ASIA-AQ Aircraft Field Campaign ***Jung-Hun Woo***

11:45 –12:00	Ensemble Source Attribution of Wintertime $PM_{2.5}$ in South Korea during the ASIA-AQ Campaign ***Hyeonmin Kim***
12:00 –13:30	**Lunch Break**
Session 5.3	**Session Chair: Chul Han Song**
13:30 –13:45	Model-assisted estimates of aerosol fine mode fraction and $PM_{2.5}$ from HSRL-2 ***Pablo Saide***
13:45 –14:00	Evaluation of Spatiotemporal Variabilities in GEMS NO_2 Retrievals using the Strategically Networked Ground-based Instruments during ASIA-AQ Campaign in South Korea ***Ukkyo Jeong***
14:00 –14:15	Trace Gas Profile Measurements from MAX-DOAS and Heterogeneity Effects on Validations for Satellite Measurements ***Hyeong-Ahn Kwon***
14:15 –15:45	Priority findings and remaining gaps for Korea's RSSR ***Discussion*** ***Leads: Rokjin Park and Jhoon Kim***
15:45 –16:15	**Tea Break**
16:15 –16:30	**Final Summary/Wrap-up**: Next Steps and Nominal Timeline for Completing RSSRs
16:30 –16:45	**Closing Remarks**
16:45	Adjourn

Poster Presentation

Poster No	Title/Presenter
1	Biomass Burning Influenced Actinic Flux from Airborne Measurements and Aerosol-Constrained Models ***Samuel Hall***
2	Evaluation of Formaldehyde Observations and Modeling Results in Central and Southern Taiwan during the KPEx Field Study ***Pei-Yu Chien***
3	Temporal Variation of NO_2 and HCHO in Bangkok (Thailand) and Dhaka (Bangladesh) from Pandora Measurements ***Minjee Kim***
4	Evolution of Lee-side vortices with pollutant transport during KPEx in Taiwan ***Min-Chuan Hsiao***
5	Air Quality Simulation over Thailand: Impact of Biomass Burning During the ASIA-AQ Campaign ***Hyerim Kim***
6	Aerosol PFAS Characteristics and Potential Sources Around Southern Taiwan ***Yu-Lun Hsieh***
7	The Effect of Biomass Burning on Air Quality in Thailand ***Hye Jung Shin***
8	Comparative Analysis of $PM_{2.5}$, O_3, and NO_2 in Southern Taiwan: Evaluating G-III and Satellite, DC-8 and UAV, and Low-Cost Sensors during the Asia-AQ/KPEx ***Jui-Hsin Hsu***
9	Ground-based Source Sampling of VOCs in Seoul and Bangkok during ASIA-AQ ***Isobel Simpson***
10	Spatiotemporal Occurrence and Characteristics of Microplastics during 2024 Kao-Ping Experiment ***Thi Hieu Le***
11	Investigating Air Pollution Sources in Southeast Asia using Airborne Observations of Ethane from Aerodyne’s Tunable Infrared Laser Direct Absorption Spectrometer during ASIA-AQ ***Victoria Wright***

12	Overview of the Database for 2024 Springtime Kao-Ping Experiment (KPEx) in Southern Taiwan ***Chia-Ching Lin***
13	Aerosol Halogen Measurements during ASIA-AQ Within a Global Context ***Jose L. Jimenez***
14	Integration of modeling, Photochemical Assessment Monitoring Stations (PAMS) and NOz measurements to evaluate the ozone production efficiency (OPE) in a downwind rural site in KPEx ***Pei-Chen Ma***
15	In-situ Airborne Instrument: Meteorological Measurement System (MMS) ***Ju-Mee Ryoo***
16	Three-Dimensional Analysis of Meteorological Parameters and $PM_{2.5}$ Distribution Using a Miniature Radiosonde System during the KPEx ***Chiao-Ling Pan***
17	Multi-model Comparison of Ozone and $PM_{2.5}$ in Thailand, Taiwan, and the Philippines ***Katherine Travis***
18	Insights from the 2024 Kao-Ping Experiment (KPEx): Variations in the Chemical Properties of Ambient Aerosols in Southern Taiwan ***Weng Wei Cheng***
19	The Broad Capabilities of the US Navy's COAMPS Model ***Nicholas Gapp***
20	Development and Validation of a UAV-Based Measurement System for Atmospheric and Air Quality Parameters in the KPEx ***Li-Jin Ke***
21	Investigation of the Spatial and Temporal Distribution of Ammonia Over Asian Countries using Integrated Airborne and Satellite Data During ASIA-AQ Campaign ***Chisung Yun***
22	Tropospheric Ozone Variability over Southeast Asia during ASIA-AQ 2024 ***Steven Kong***
23	Characterization of Atmospheric Black Carbon during the ASIA-AQ Campaign ***Minwoo Baek***

24	Evaluation of CMAQ model (v5.3.3) over Taiwan region during the 2024 Kao-Ping (KPEx) Experiment ***Steven Soon-Kai Kong***
25	Analyzing Air Quality Patterns in Thailand and the Philippines using Satellite Data ***Seonggyun Na***
26	Aerosol Size Distribution and Chemical Composition from ASIA-AQ Taiwan KPEx Southern Taiwan Super-Site ***Chih-Yu Chan***
27	Observations of PAN in Taiwan and Thailand and an Assessment of PBzN and Aromatic Chemistry ***Linda Arterburn***
28	Airborne Observations of Refractory Black Carbon: Variability in Mass Concentration, Size Distribution, and Mixing State Across the Philippines ***Shalini Mishra***
29	Boundary Layer Determination Along the DC-8 Flight Track During the ASIA-AQ Campaign ***Jason Miech***
30	The spatial inhomogeneity of the PBL observed by Vehicle-based Doppler Wind Lidar during Asia-AQ-Taiwan ***Chuan-Yan Lin***
31	Intercomparison of VOC data measured by PTR-MS, TOGA, and WAS during ASIA-AQ 2024 ***Wojciech Wojnowski***
32	Estimation of Emissions Rates from Coal-Fired Power Plant using airborne measurement during ASIA-AQ Campaign ***Hyeongseok Choi***
33	Surface Meteorology and Boundary-Layer Structure During the ASIA-AQ Campaign Period ***Minsoo Kang***
34	HONO Measurement during the ASIA-AQ Campaign in South Korea and its Implication in $PM_{2.5}$ nitrate as an In-Situ Formation Indicator ***Junsu Gil***

35	Calibration and flight performance of the open-path ammonia laser spectrometer in ASIA-AQ ***Ryan Boyd***
36	Shifting Flowering Periods in A Warming Climate Observed from Long-Term Lidar Observations in Seoul ***Woojin Hwang***
37	Leveraging Formaldehyde Observations to Assess Surface Air Quality ***Prajjwal Rawat***
38	Multi-model Intercomparisons of Air Quality Simulations for the ASIA-AQ Campaign ***Jaein Jeong***
39	Investigations of Oxygenated Aromatic Compounds in East and Southeast Asia: Observations from ASIA-AQ ***Katherine Ball***
40	Identification of Major Emission Sources of CO_2 and CH_4 in Seoul, South Korea during the ASIA-AQ Campaign ***Hyeongmo Kang***
41	GEMS Ozone Measurements ***Jaehwan Kim***
42	Evaluation of Spatiotemporal Variabilities in GEMS NO_2 Retrievals using the Strategically Networked Ground-based Instruments during ASIA-AQ Campaign in South Korea ***Serin Kim***
43	Comparison of the Vertical Profile Characteristics of Ozone on the Korean Peninsula during ASIA-AQ Campaign Period ***Sang Jun Kim***
44	Regional Difference in Columnar Aerosol Chemical Composition using AERONET in South Korea during the ASIA-AQ Campaign ***Minho Kim***
45	Evaluation of Aerosol Data Assimilation and Forecasts in the NASA GEOS Model during the ASIA-AQ Campaign in Korea ***Seunghee Lee***

46	Characterization of VOCs Emissions and Spatial Distribution over Urban and West Coast Areas of South Korea: Airborne Observations from the 2024 ASIA-AQ Campaign ***Jimin Lee***
47	Comparison of Tropospheric NO_2 Vertical Column Density using Different Retrieval Algorithms from Pandora MAX-DOAS mode Observations ***Giyeol Lee***
48	Wintertime Characteristics of Particulate Matter and High-Concentration Events at Anmyeondo: Implications for Regional Air Quality Assessment ***Jihye Moon***
49	Characteristics of Atmospheric Volatile Organic Compounds from Background Coastal Area, Anmyeondo, Korea ***Hu Qihua***
50	Diurnal and Seasonal Variations of Aerosol Size Distribution and New Particle Formation (NPF) at Western Coast of South Korea: 19 Years of Long-Term Observation at Anmyeon GAW Station ***Eunho Park***
51	Seasonal Characteristics and Health Risk Assessment of Anthropogenic VOCs in South Korea ***Avinash Shastri***
52	Airborne and Ground Monitoring in SIJAQ/ASIA-AQ ***Suna Shin***
53	Role of Aerosol Liquid Water Content and pH in Inorganic Aerosols in $PM_{2.5}$ during ASIA-AQ ***Seora Woo***
54	Analysis of Long-Range Transport During the ASIA-AQ Campaign ***Wook Kang***
55	Nocturnal Chemistry of NO_3 and N_2O_5 during the 2024 ASIA-AQ Campaign: Investigating Uptake Coefficients and Nitrate Contribution in Seoul ***Jiseon Lee***
56	Analysis of Meteorological Effects on Air Quality During the ASIA-AQ Campaign ***Yesol Cha***
57	Shifts in Regional Emission Contributions During Elevated $PM_{2.5}$ Episodes in South Korea: Insights from the 2024 ASIA-AQ Study

	Seongeun Jeong
58	Analyzing the Influence of NO_2 on Aerosol through Pandora Measurements in Major Asian Cities ***Seongyoung Kim***
59	Comparison of Aerosol Vertical Information between GEMS and HSRL ***Sang Seo Park***
60	Chemical Characteristics of gaseous pollutants in West Sea of Korea using 1900D: during ASIA-AQ ***Jinsoo Choi***
61	Chemical Characteristics of Fine Particulate Matter in the Seoul Metropolitan Area and the West Coast Region: Insights from 1900D Airborne Observations ***Joon-Young Ahn***
62	Aerosol Properties over the Yellow Sea Region – South Korea ***Francesca Gallo***

附錄 3、會議資料

Overview of the Kao-Ping Experiment (KPEx) in Southern Taiwan during ASIA-AQ

Neng-Huei (George) Lin
National Central University (NCU), Taiwan

Contributors: HC Lai, SH Wang, TC Hsiao, JL Wang, CT Lin, LC Wang, YI Tsai, CF Ou Yang, CS Yuan, SL Lin, KH Chi, GR Sheu, MC Liang, WT Liu, KS Kong, WS Huang, JY Yu, PF Shieh, Hal Maring4, SC Tsay, E Welton, Jim Crawford, etc.

- KPEx: AP sources, transformation, transport and impact studie; 3-D observations
- 2024 Mid-Feb to March NASA/ASIA-AQ overflights in southern Taiwan (Kao-Ping area, including western/central Taiwan)

7 SouthEast Asian Studies (7-SEAS) since 2007

GSFC

NCU

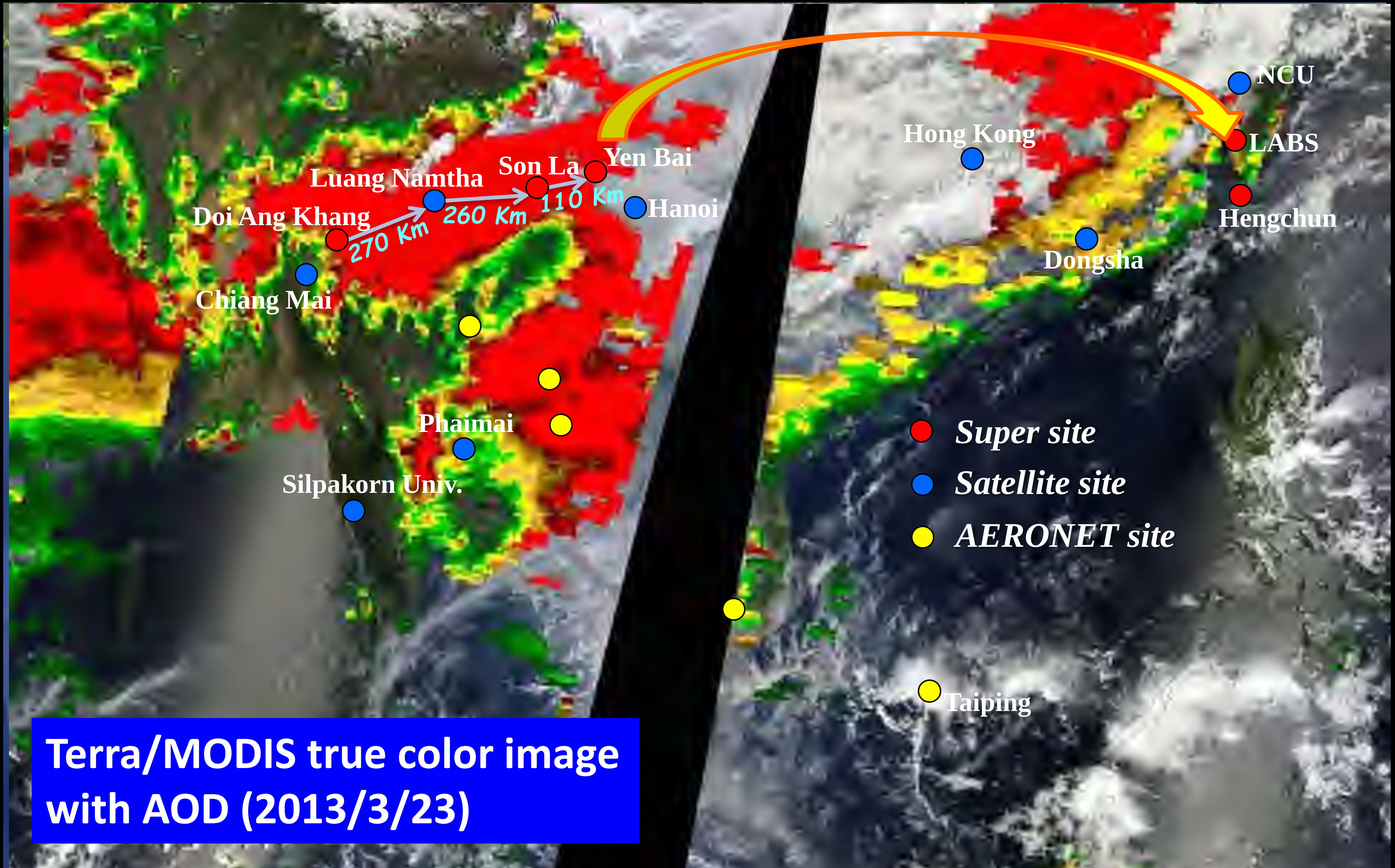
Taiwan EPA

Malaysian Meteorology Service

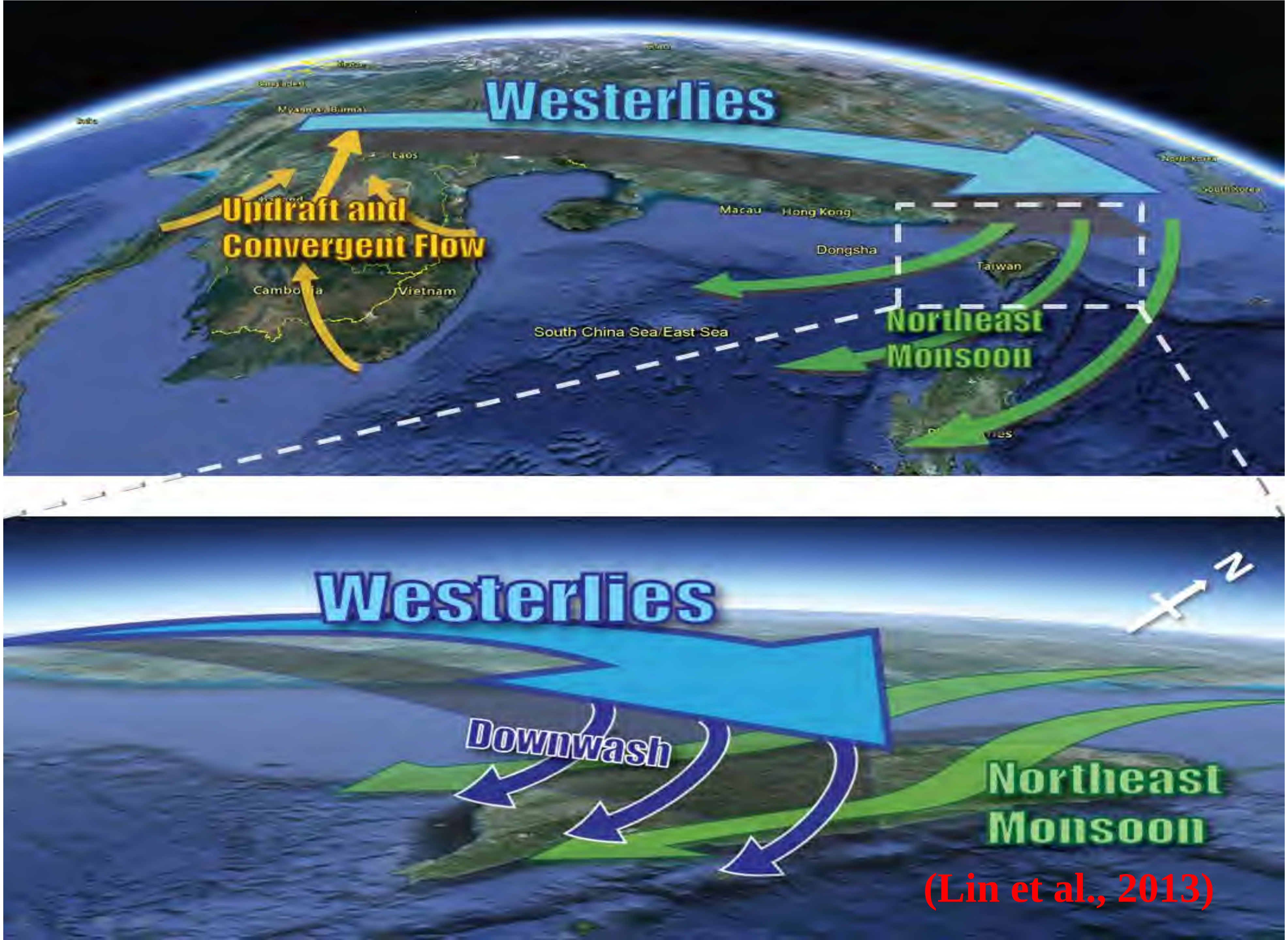
**Hal Maring, Jeff Reid,
Brent Holben, Si-Chee Tsay,
Christina Hsu, Judd Welton,
George Lin, Nguyen Xuan Anh,
Somporn Chantara, Santo Salinas,
………….**

Review and overview of 7-SEAS:
Reid et al., 2013
Lin et al., 2013, 2014
Tsay et al., 2016

Previous 7-SEAS Spring field campaigns



Review and overview of 7-SEAS: Reid et al., 2013 Lin et al., 2013, 2014 Tsay et al., 2016

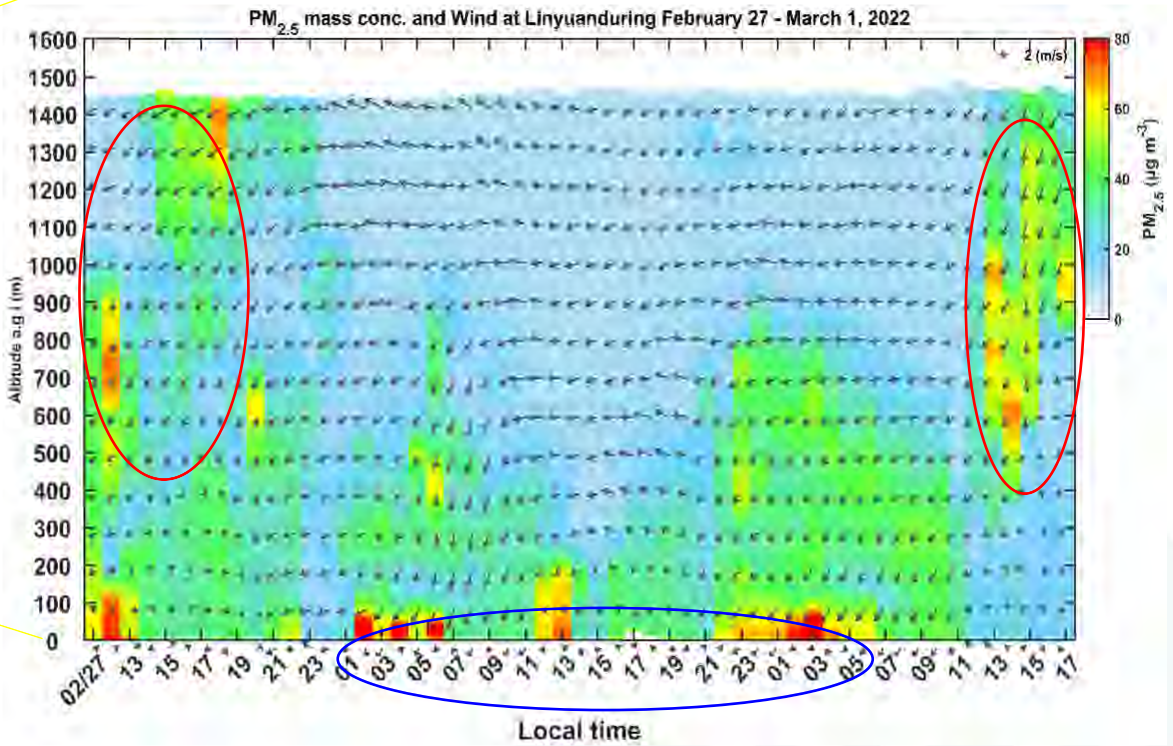


(Lin et al., 2013)

A pilot study of KPEx - UAV/$PM_{2.5}$ in Kao-Ping (KP)

27 Feb – 1 Mar 2022

Hourly $PM_{2.5}$ and wind vector in vertical

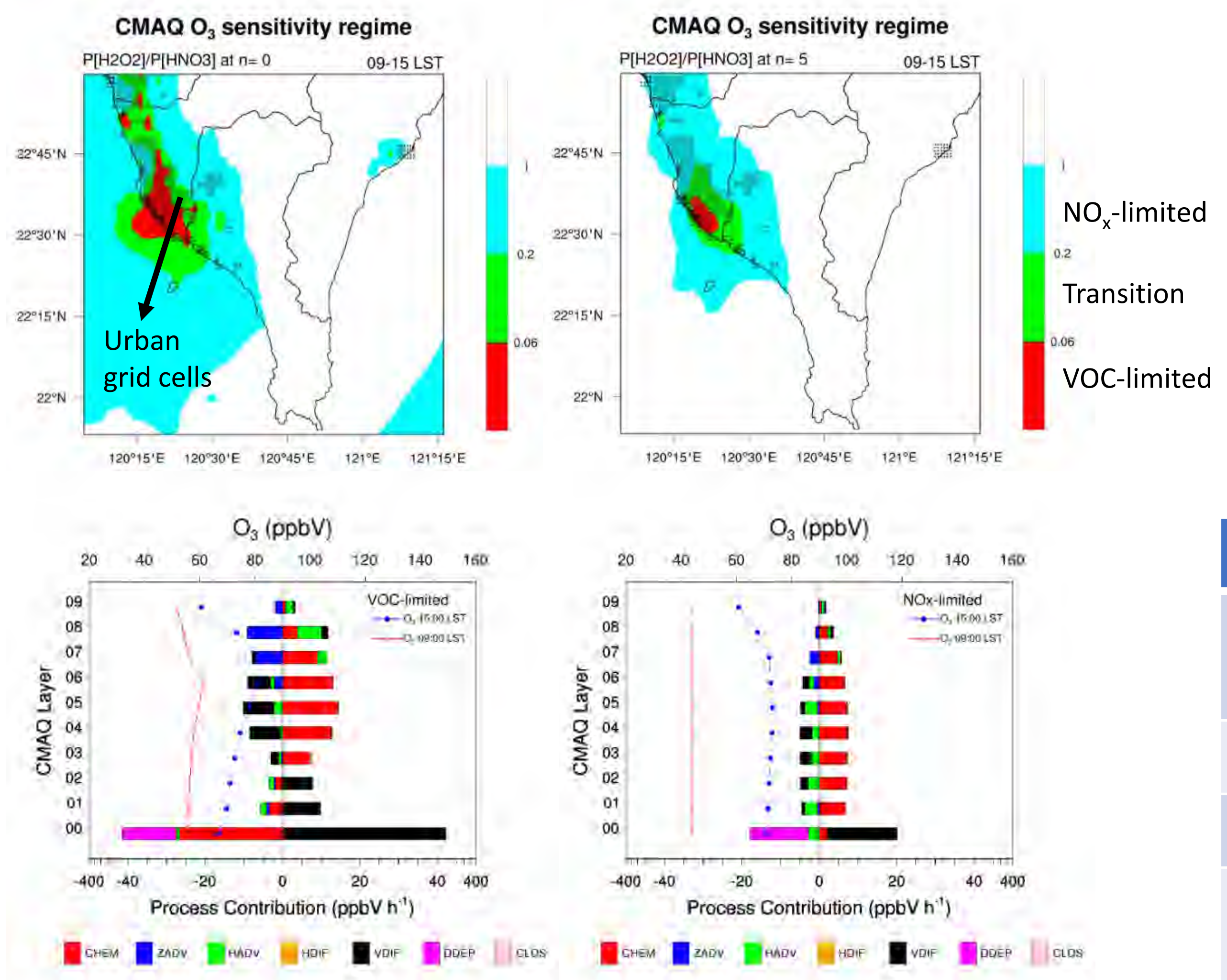


Two-layer structure:

- **$PM_{2.5}$ at higher level due to upwind transport**
- **$PM_{2.5}$ accumulated at lower level due to leeside and wake effects**

(Carlo Wang)

WRF/CMAQ 1km x 1km UHI-Ozone case study



Vertical Profile O_3:

VOC-limited vs. NO_x-limited

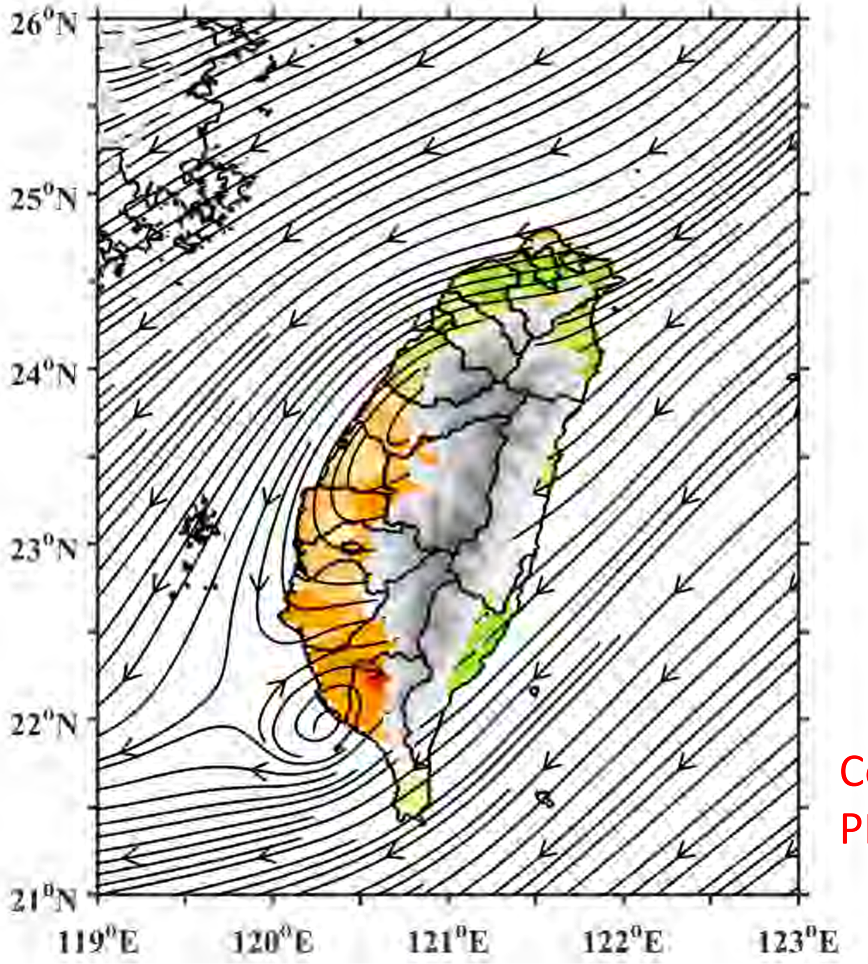
- Most of the urban area in the coastal region is classified as VOC-limited regime.
- Inland area as NO_x-limited regime.

VOC-limited	NOx-limited
Titration effect is dominant at low level	**CHEM** is always positive across all levels
O_3 profile is not well-mixed	O_3 profile is well-mixed
Enhanced **CHEM** at n=5	**CHEM** is nearly constant
Physiochemical circulation is obvious (**CHEM**/**VDIF**)	No physiochemical circulation

(Chang et al., 2022)

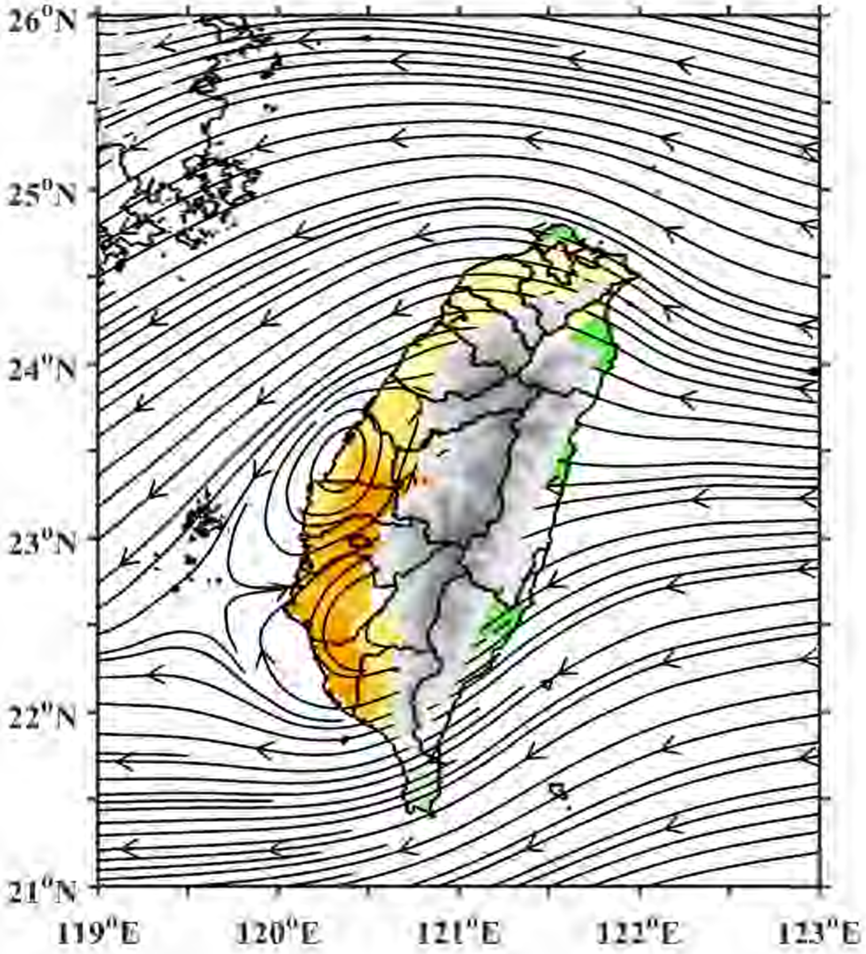
High $PM_{2.5}$ event

Prevailing Northeast wind



Contour presents
$PM_{2.5}$ concentration

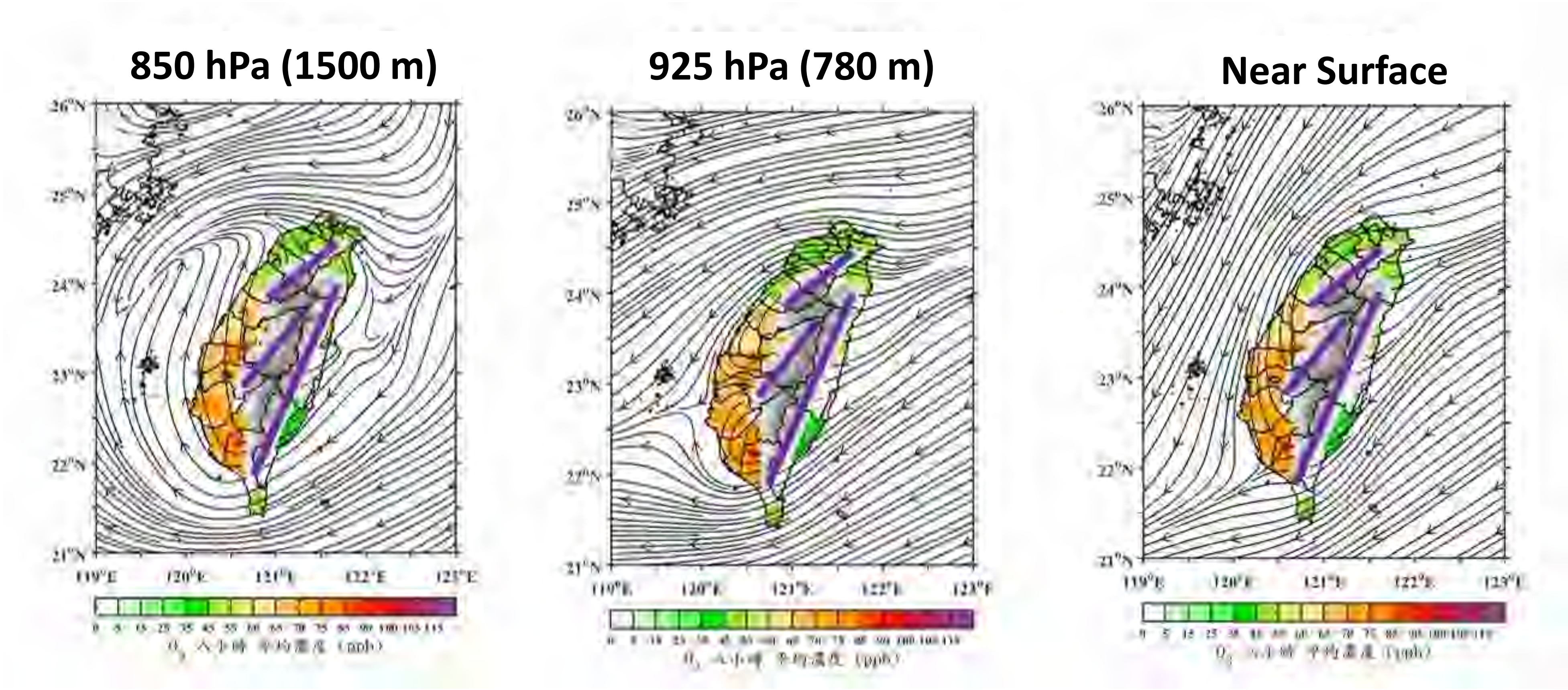
Prevailing East wind



(HC Lai)

High O_3 event

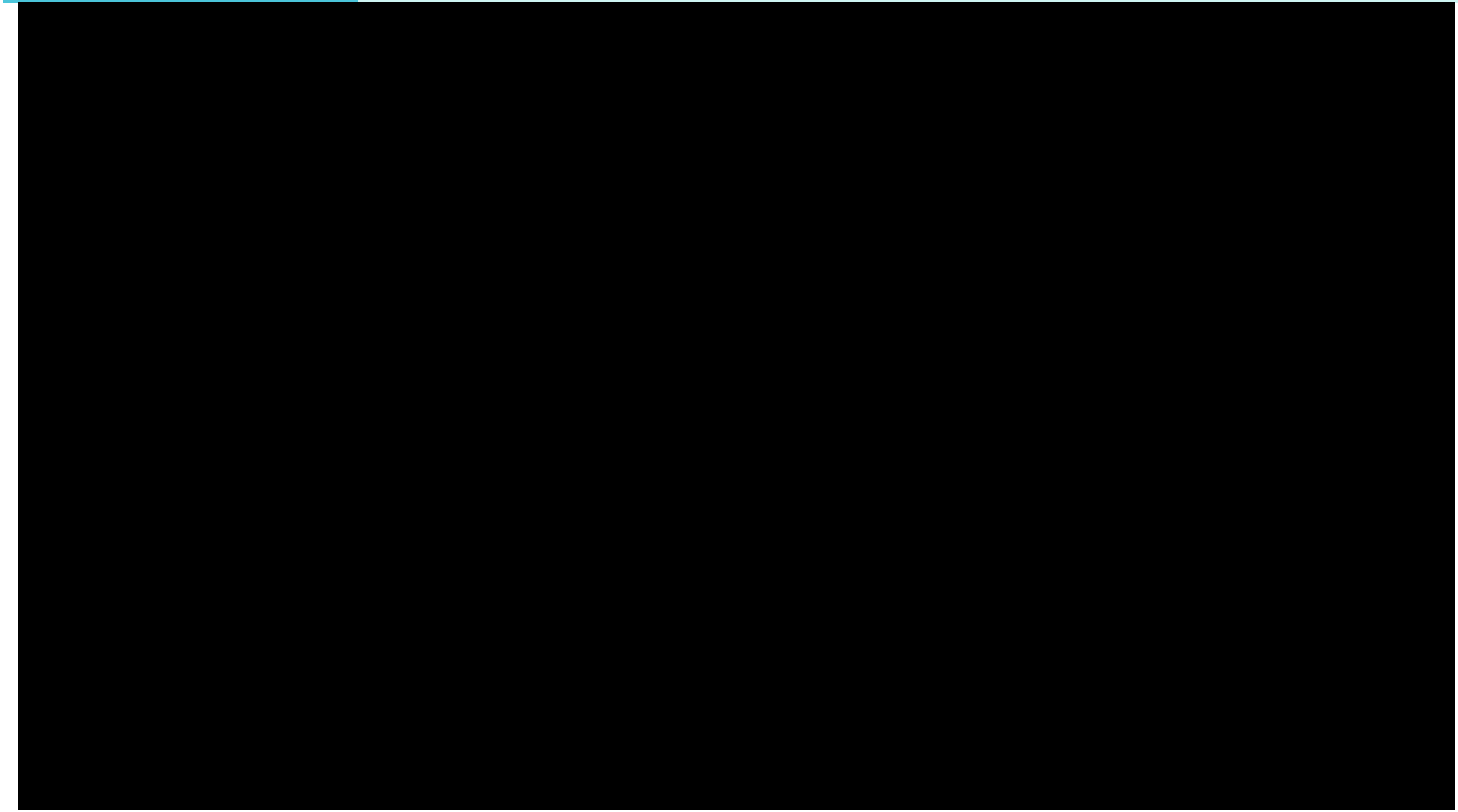
Prevailing East wind
(Siberia High system moving into West Pacific)



Contour presents 8-hr O_3 concentration

(HC Lai)

3-D KPEx: Ground-based and vertical observations

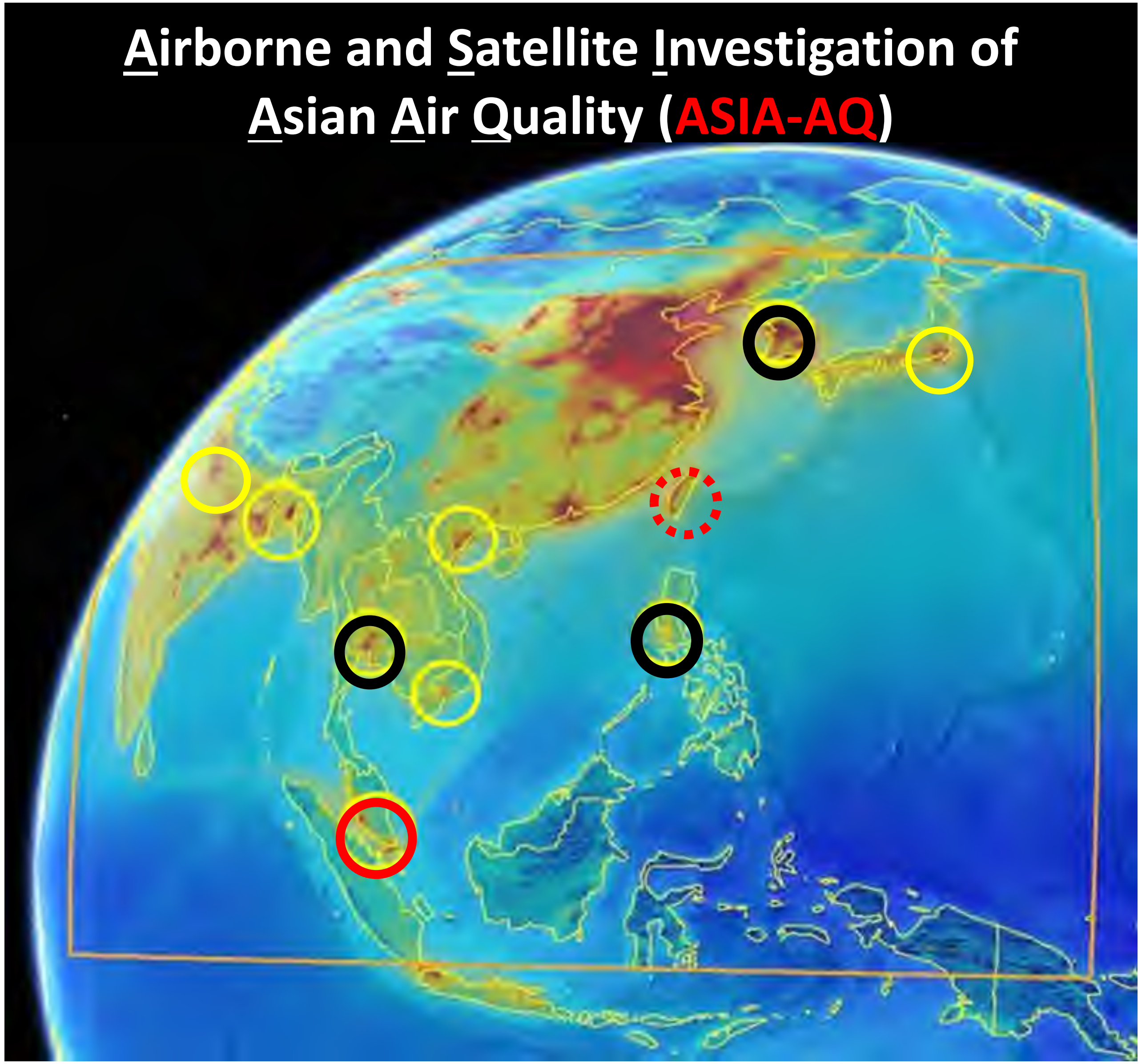


7-SEAS/Kao-Ping Experiment (KPEx)

February-March 2024

- Process of ozone and SOA formation
- Cause of visibility deterioration in Kao-Ping area
- Role of local and regional circulations and terrain effects on local AQ
- Resolving vertical profiles of pollutants and atmospheric structure, and effect on local AQ
- How well can the AQ model perform in KP area?
- How can remote sensing enhance the monitoring capacity on AQ
- Source identification and air pollution control strategies

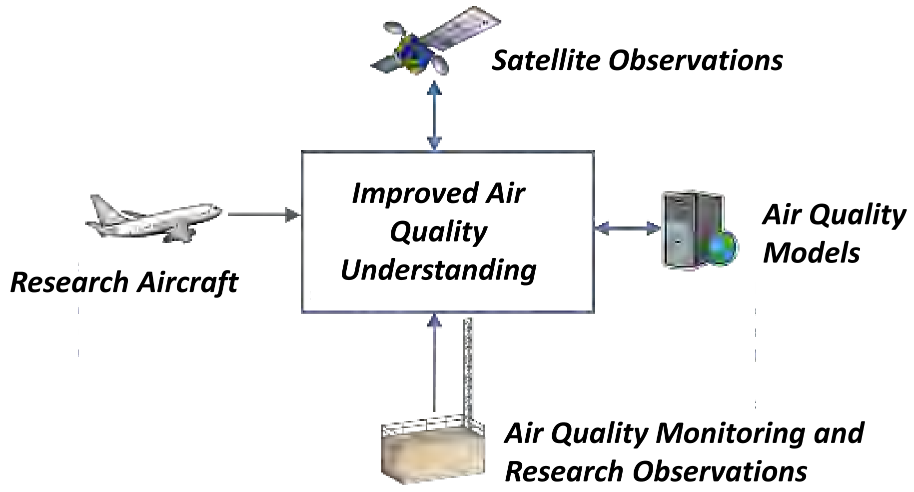
NASA/ASIA-AQ



Purpose: Improve understanding of the factors controlling local air quality across Asia through multi-perspective observations and modeling

Approach: Conduct airborne sampling across two to three locations in collaboration with local scientists, air quality agencies, and other relevant government partners.

Philosophy: Openly share data during all phases, conduct joint analysis with local scientists and air quality agencies, and report findings to local governments



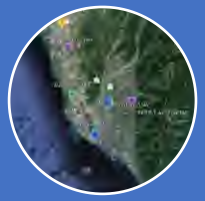
(Jim Crawford)

DC-8 and GIII overflight tracks

(Jim Crawford)

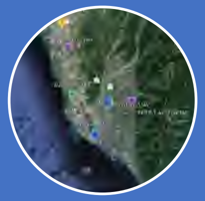
4 IOPs of KPEx in line with ASIA-AQ

- IOP-1: 2/15 – DC-8/G-III
- IOP-2: 2/28 – NA G-III
- IOP-3: 3/13 – DC-8/G-III
- IOP-4: 3/27 – DC-8/G-III

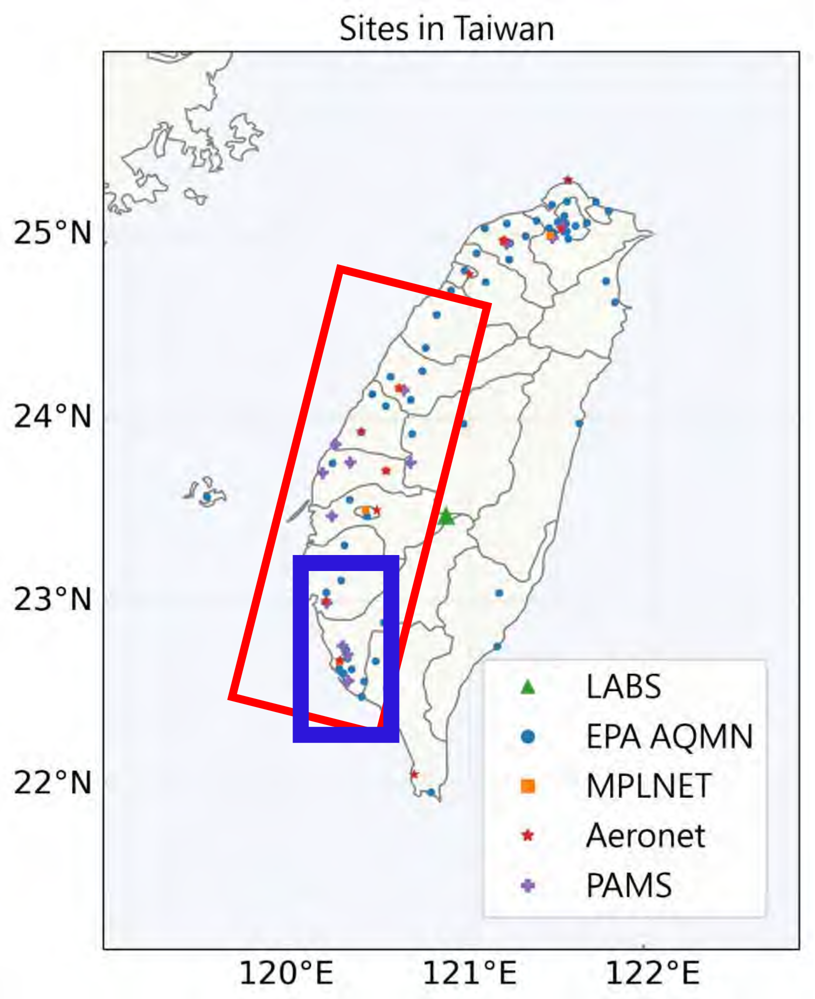


-24 hours

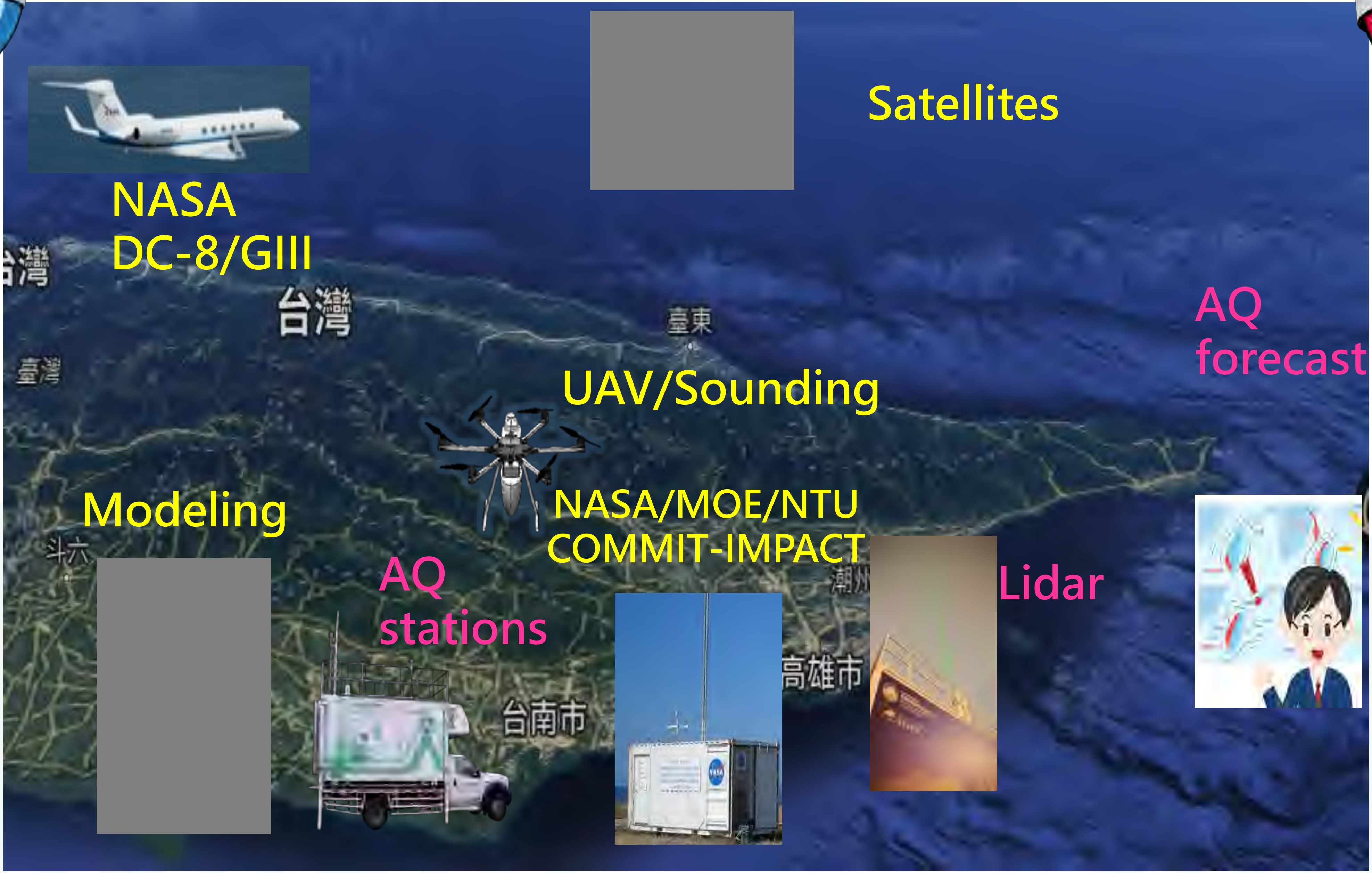
AQ flights



+24hours



3-D KPEx + ASIA-AQ



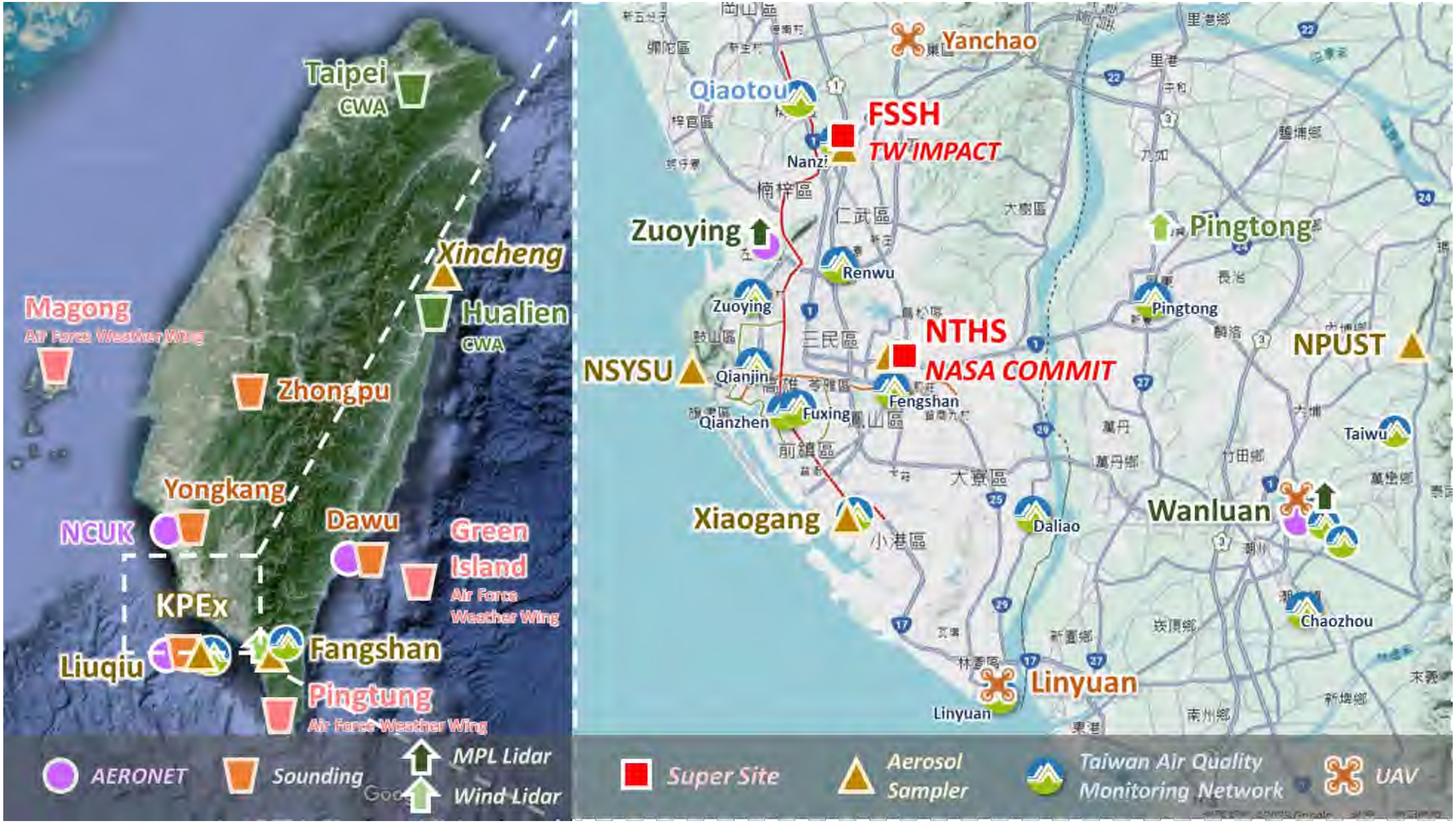
KPEx major tasks

- Regional flow and local circulation
- Vertical profiling of pollutants and atmospheric structure
- AQ: ozone/aerosol/POPs/HAPs chemistry
- Visibility: aerosol physical/optical properties
- Source apportionment
- Model validation and improvements
- Remote sensing validation and application

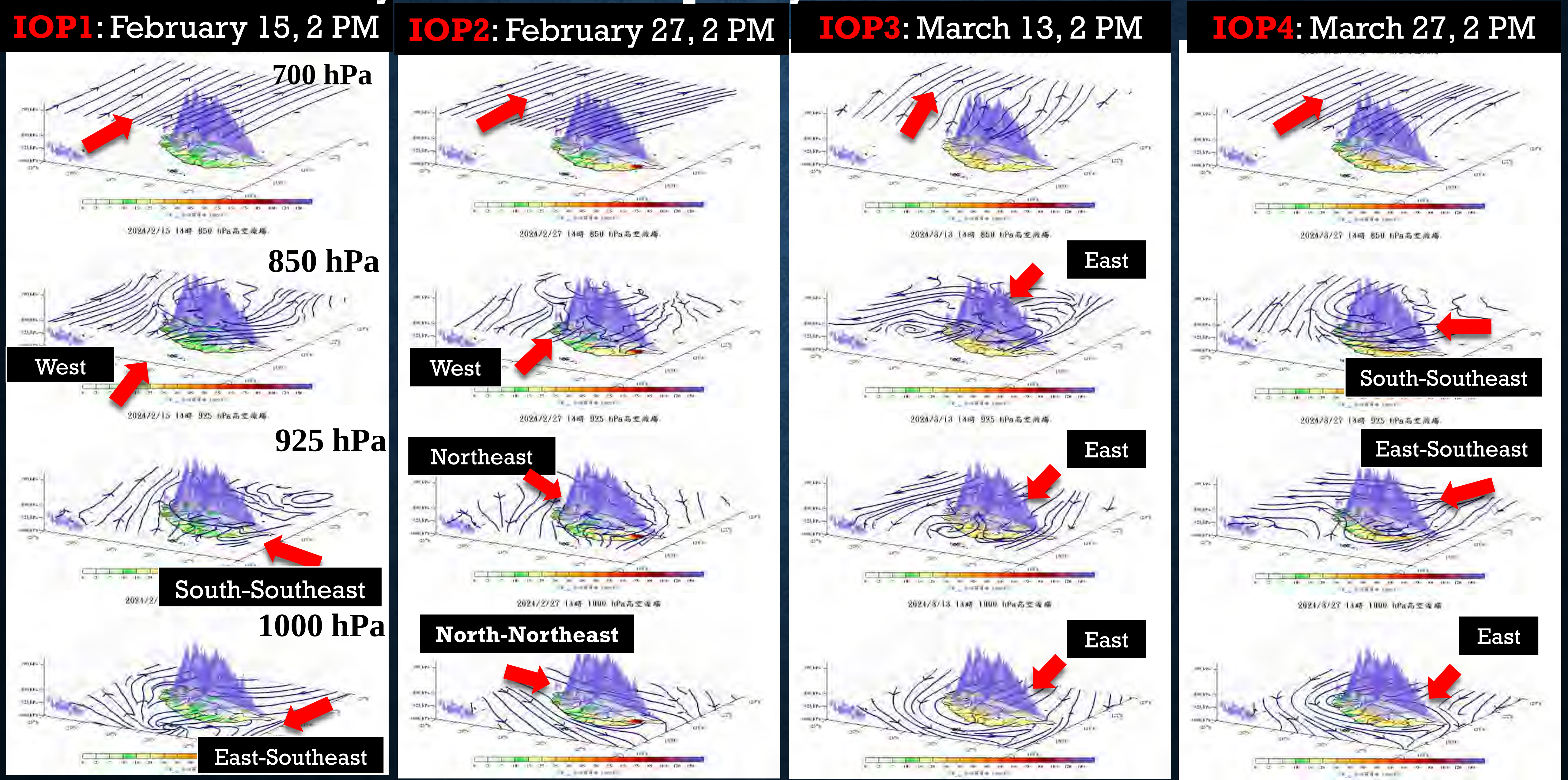
Session III: KPEx & ASIA-AQ

16 talks and 13 posters

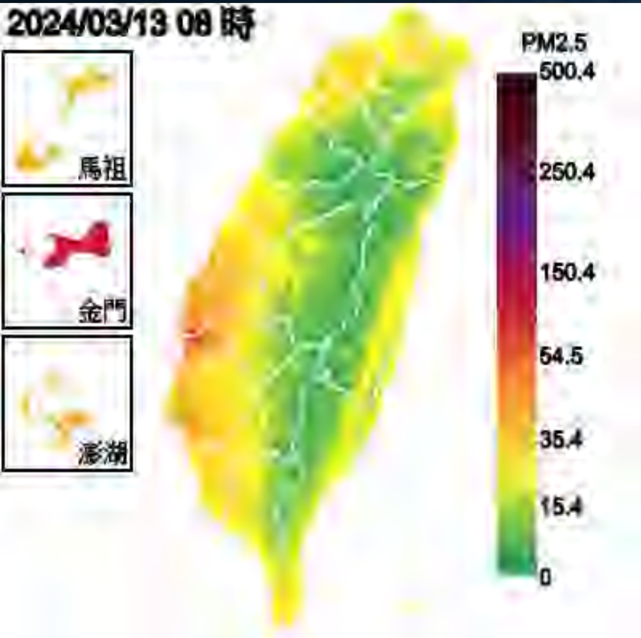
Sites in KPEx – Sounding/UAV and physics/chemistry of pollutants

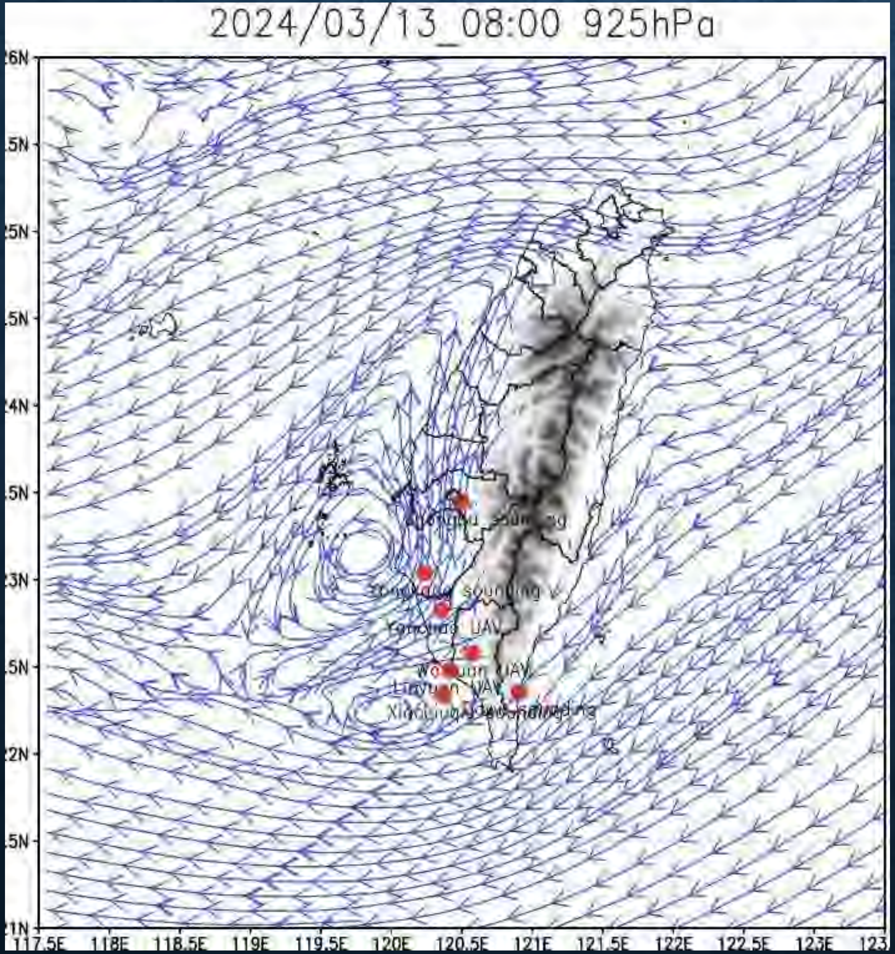


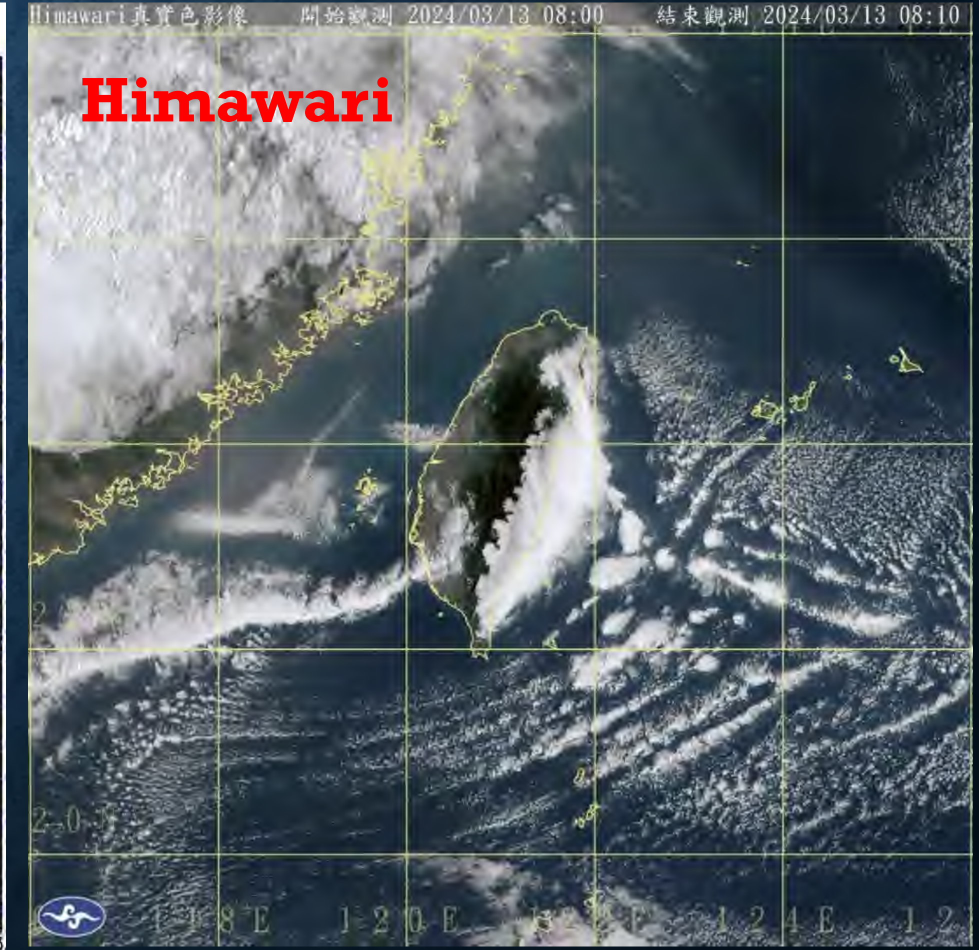
Interaction of environmental vertical wind fields and terrain effects is a key issue for air quality in southern Taiwan. (HC Lai)

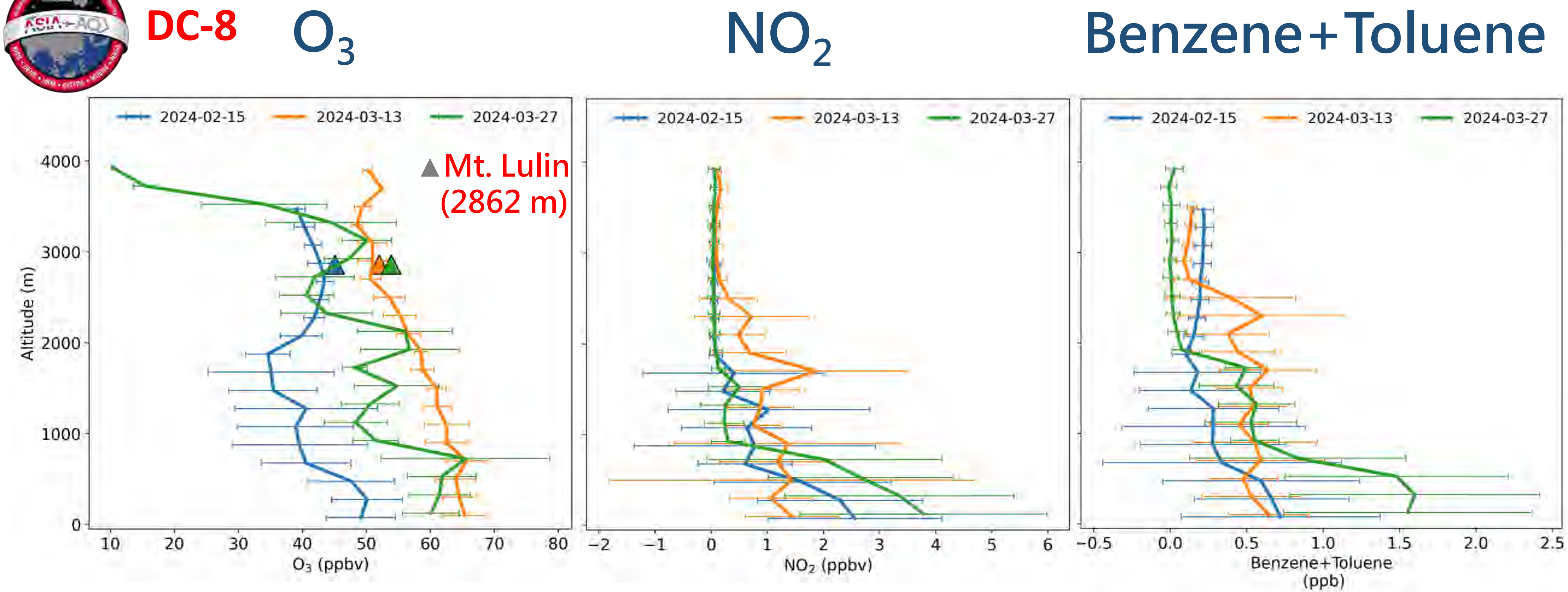


IOP-3 March 13: The region of higher $PM_{2.5}$ was shifted from southern to central Taiwan due to leeside vortices. Satellite imagery clearly shows a line cloud band in the southwestern Taiwan Strait, as well as circular cloud band in the north. The positions of $PM_{2.5}$ accumulation, vortices, and cloud bands all align well.





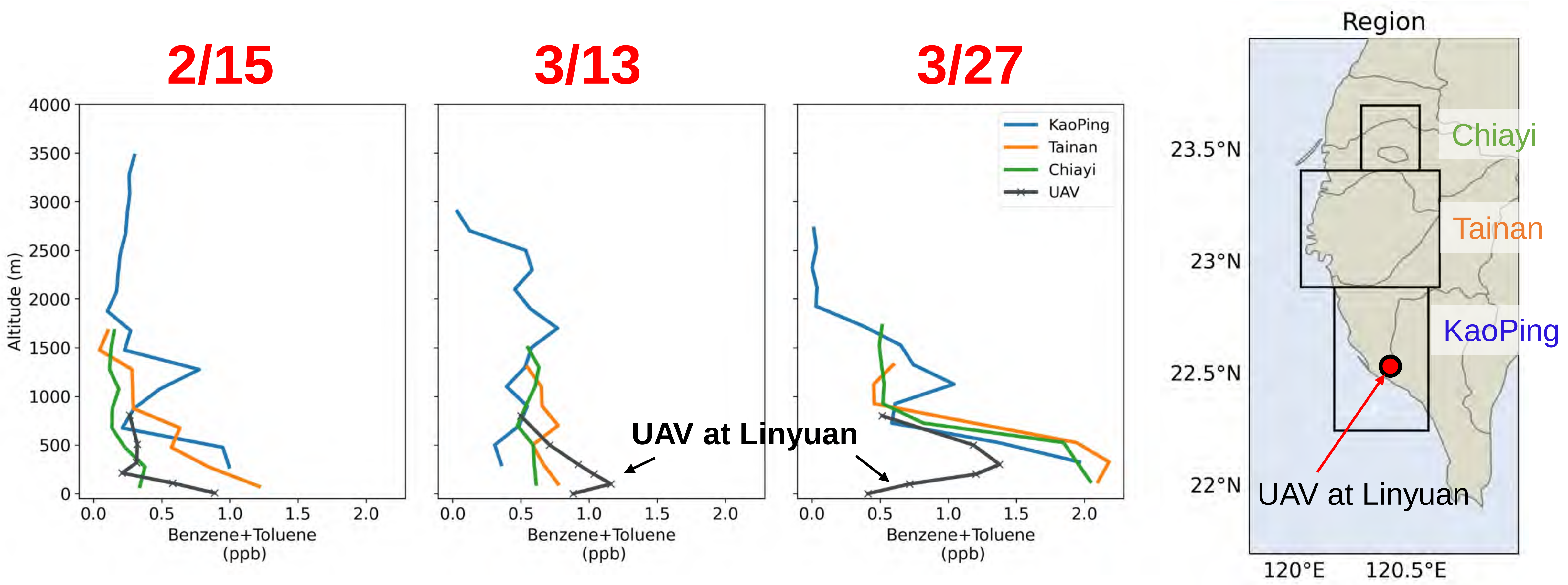




- Average profile data shows that during IOP1 (2/15) and IOP4 (3/27), there is an increase in concentration within the boundary layer (below 800 m), with ground-level pollution being more significant during IOP4 (3/27) compared to IOP1 (2/15).
- During IOP3 (3/13), the lower levels were likely dominated by local pollution accumulation in the central and southern regions, while the middle and upper levels were influenced by external sources. Therefore, the concentration differences between the higher and lower levels were not significant.

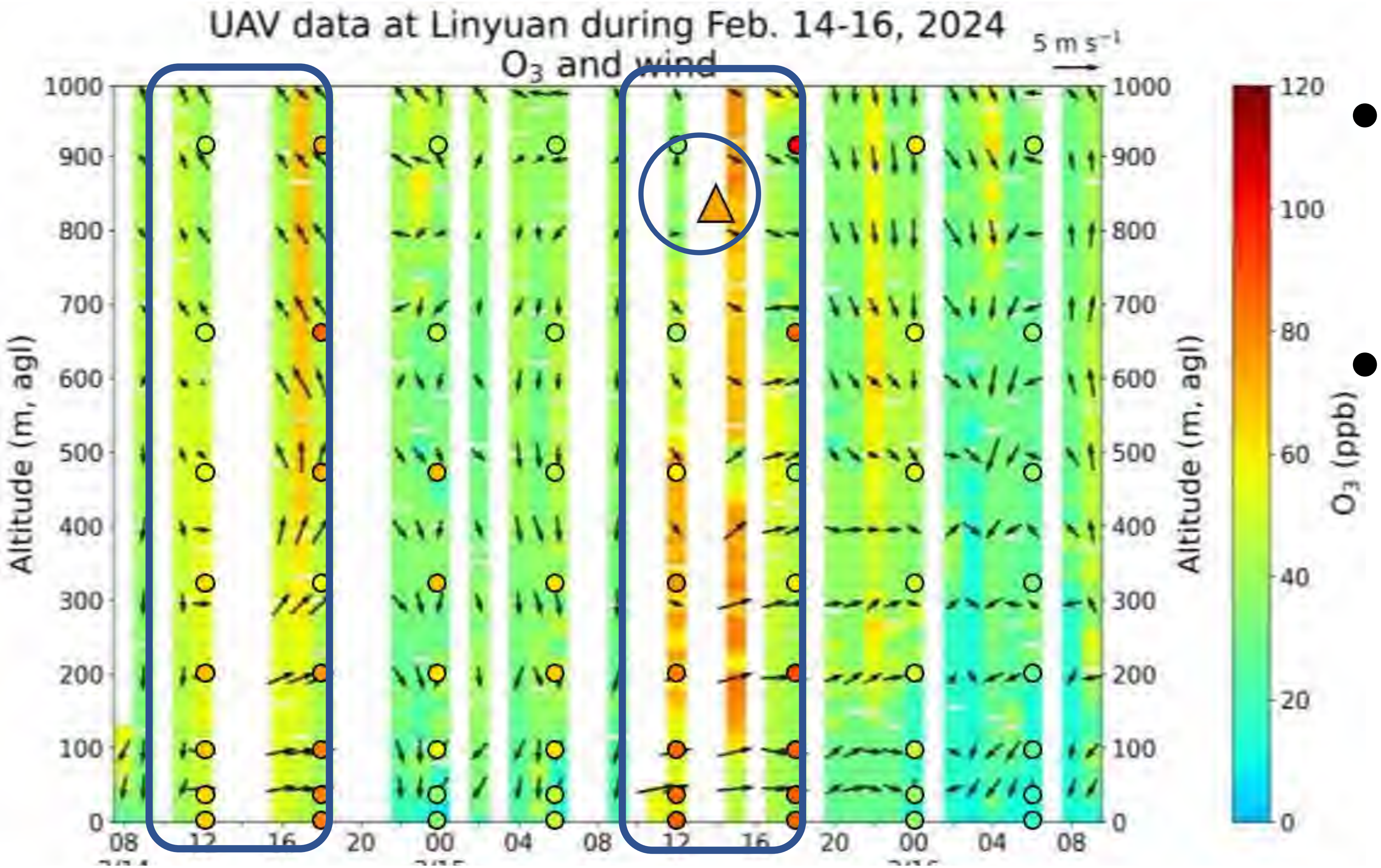
Data credit: O_3 (Jason M. St. Clair), NO_2 (Jason M. St. Clair), Benzene&Toluene (Armin Wisthaler)

DC-8 and UAV (Ben.+Tul.) in 3 regions in S. Taiwan



- Similar results of DC-8 and UAV are suggested, using benzene and toluene data as representatives.
- Similar homogenous vertical pattern of DC-8 and UAV benzene and toluene data were found in IOP3 on 13 Mar.
- Significant increased level of benzene and toluene was observed within 500 m.

IOP1: Comparison of O_3 by UAV, DC-8 and CMAQ in Linyuan

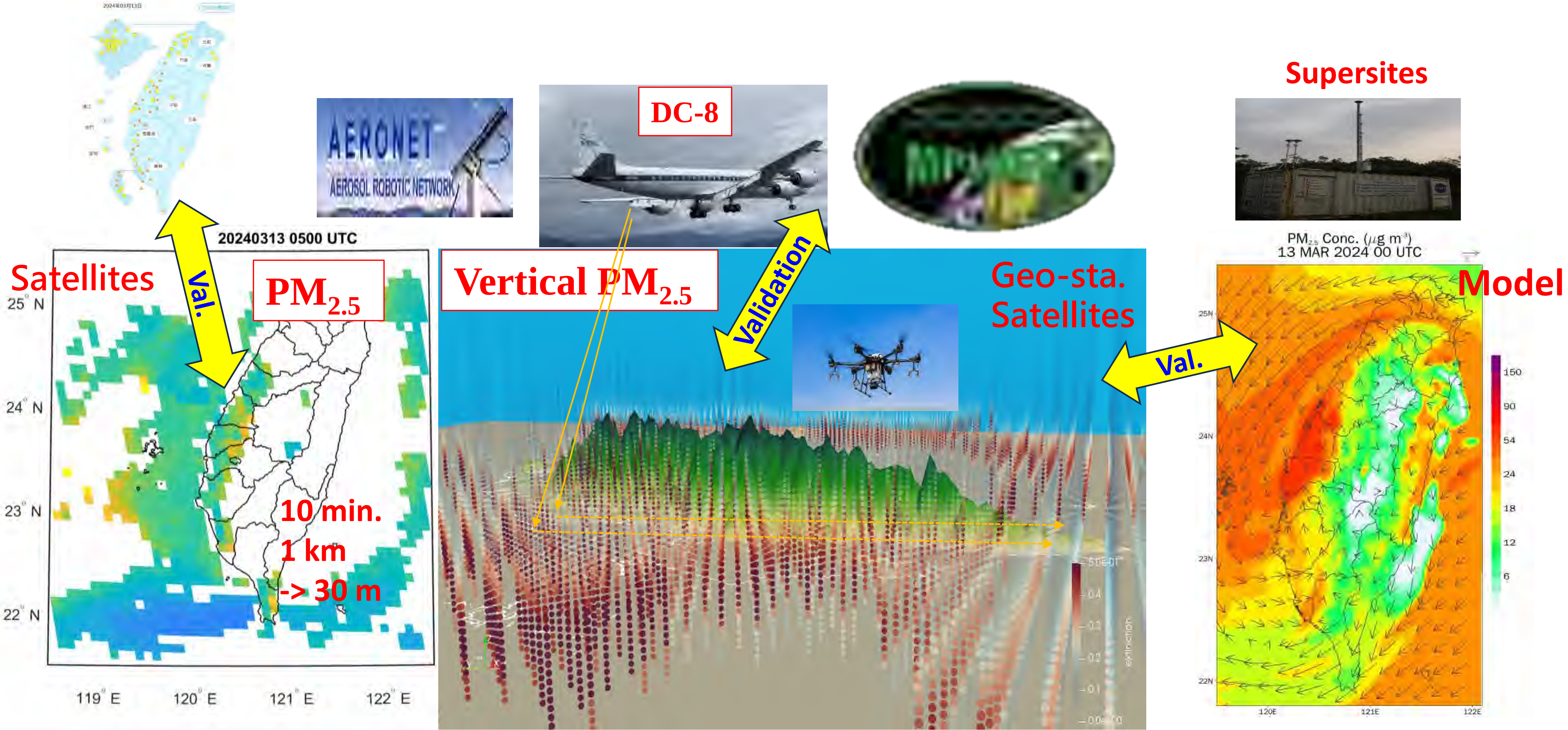


- Vertical O_3 for UAV, DC-8 and CMAQ were comparable.
- CMAQ $PM_{2.5}$ in higher levels were significantly under-predicted, compared with UAV observations.

Color – UAV; ○ - CMAQ; △ - DC-8 within 5km of Linyu site

Present vs. future

Ground-based and 3D obs. and near real-time forecast



Data availability:

- Upon request
- Will be uploaded soon on
  KPEx website
  ASIA-AQ database

Contact: George Lin
nhlin@cc.ncu.edu.tw

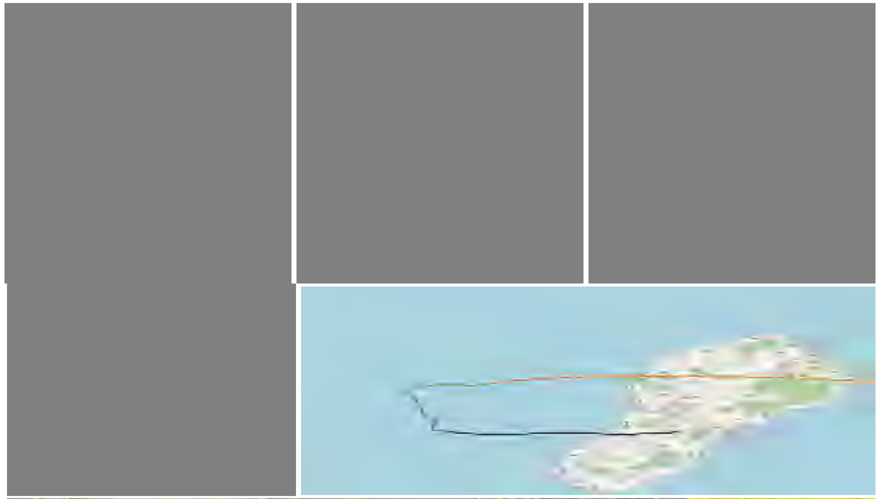

Together, we can safeguard our blue skies.

Terrain Effect on Vertical Atmospheric Structure in Taiwan during KPEx/ASIA-AQ

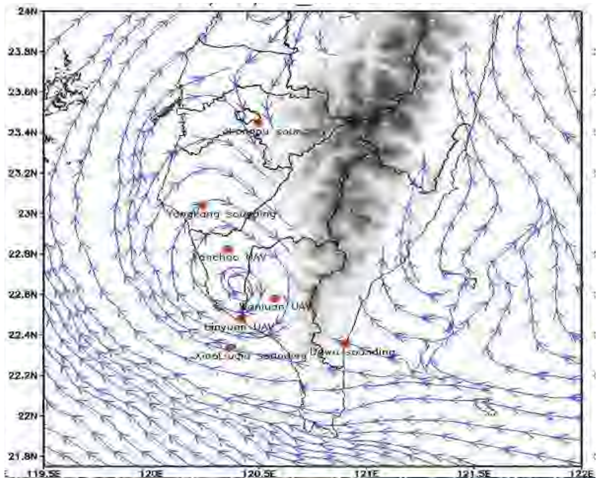
環境部
Ministry of Environment

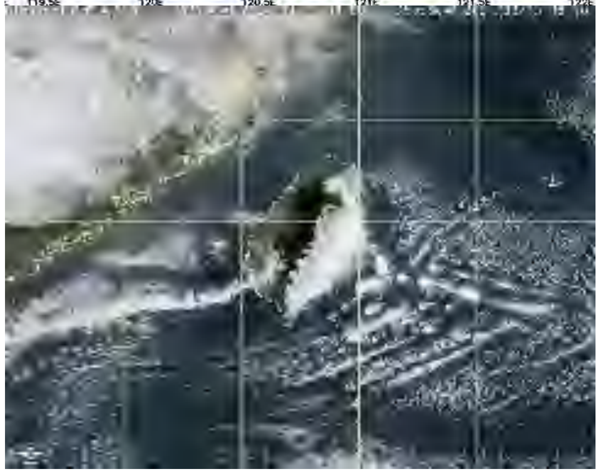
NASA DC8 and GIII flight routes

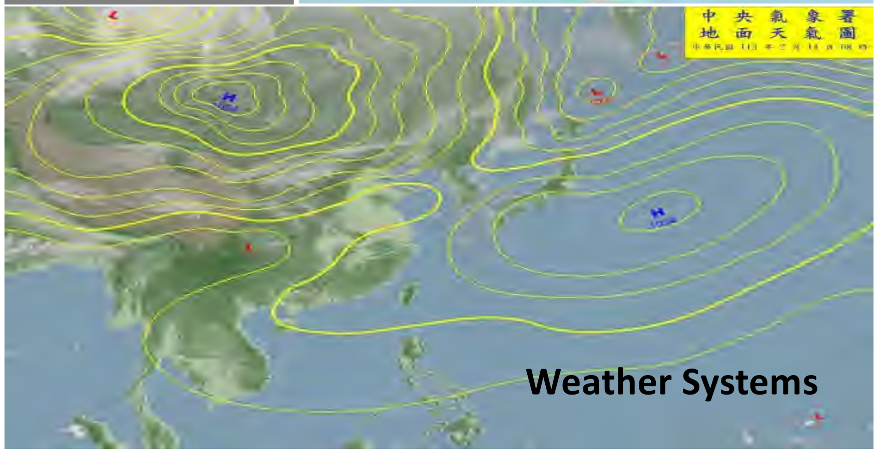
Vertical Atmospheric Conditions



Flow Characteristics







Hsin-Chih Lai,

Wei-Kuo Soong,

Ching-Hwang Liu ,

Sheng-Hsiang Wang,

Neng-Huei Lin

長榮大學 Chang Jung Christian University

空軍航空技術學院 AIR FORCE INSTITUTE OF TECHNOLOGY

中國文化大學 CHINESE CULTURE UNIVERSITY

國立中央大學 National Central University

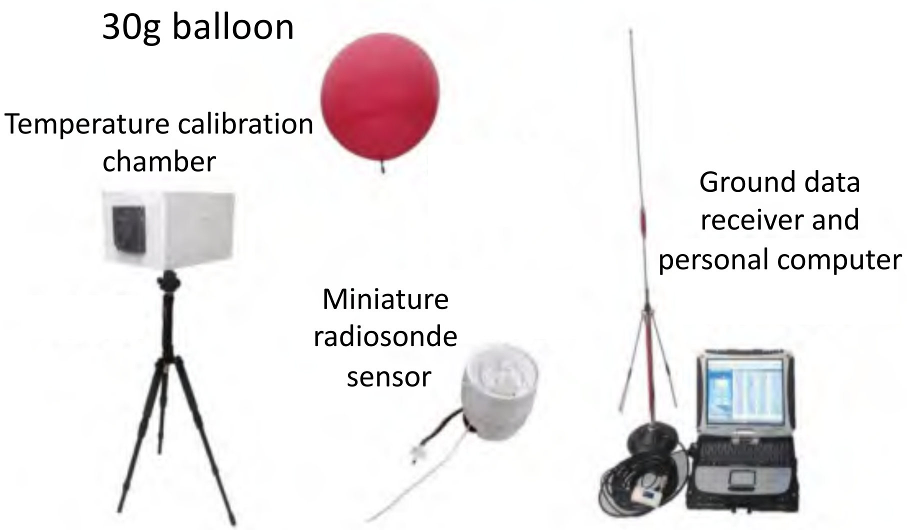
Field Experiment Design

- **Synoptic flow: Soundings, CWA、 CAF**
- **Regional flow: AeroSondes, KPEx**
- **Local flow: UAVs, KPEx**

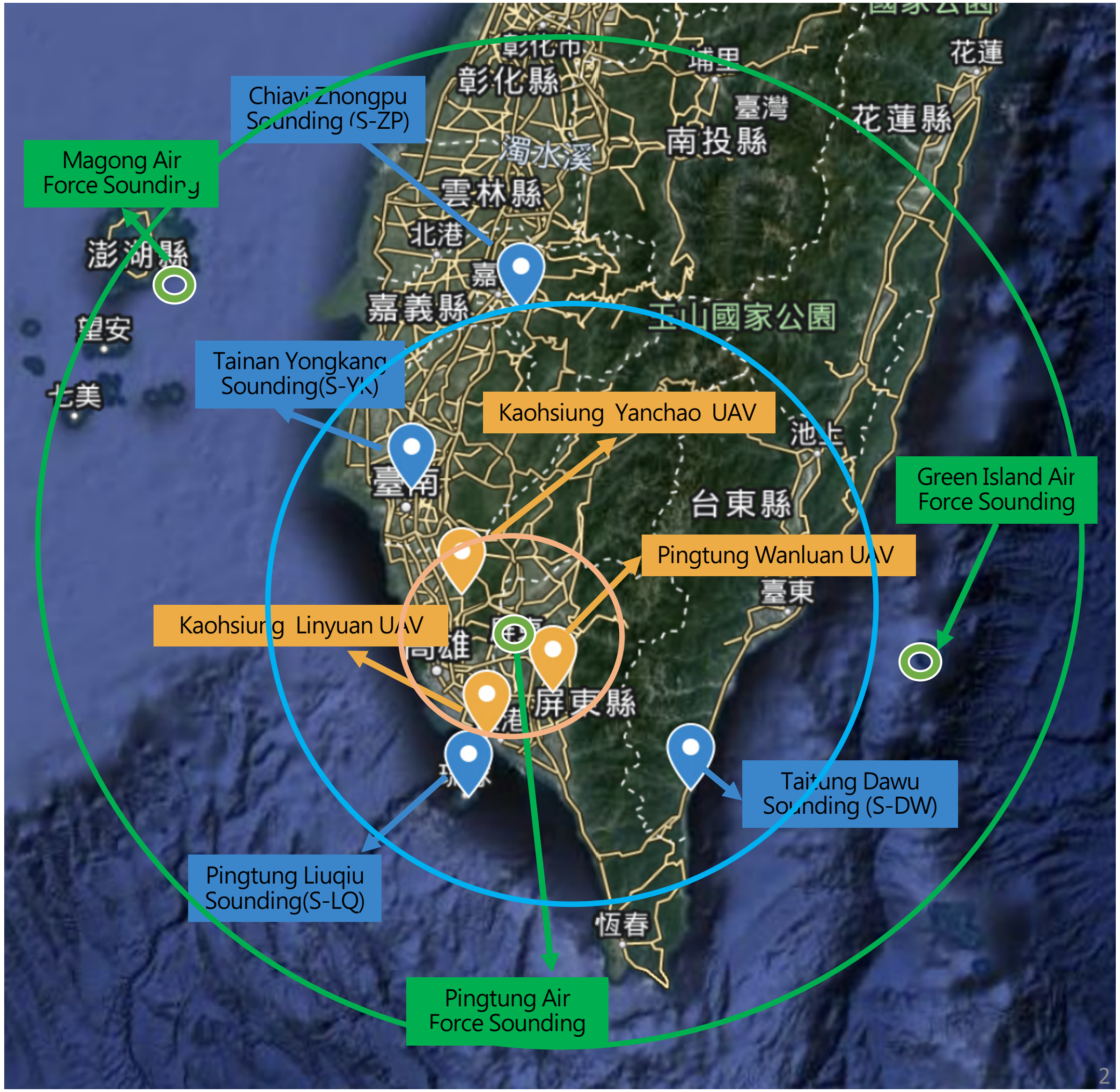
IOP dates

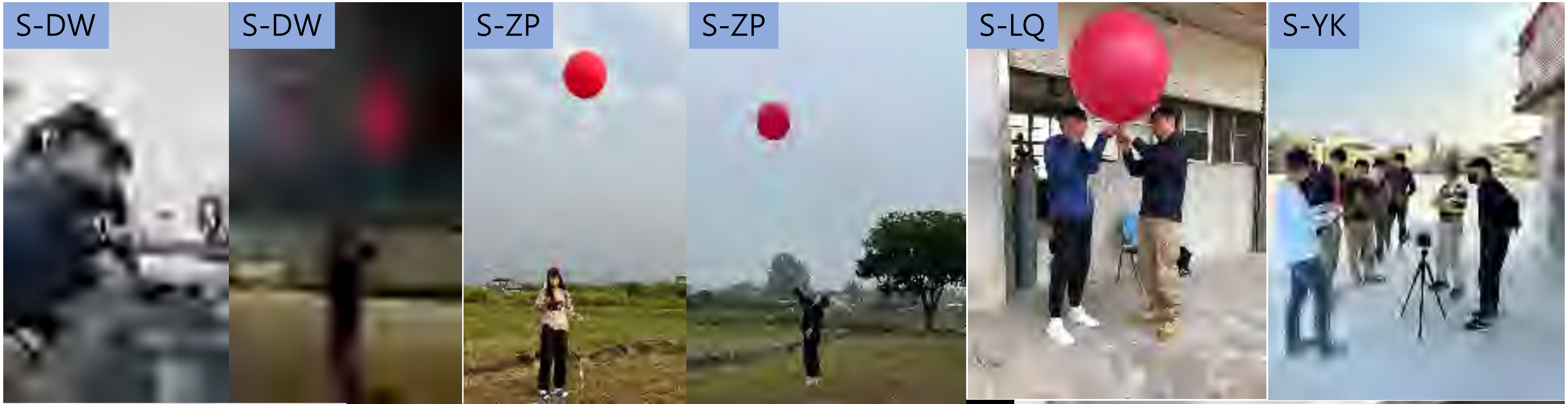
IOP1: 2024/02/14-16，**IOP2:** 2024/02/27-29
IOP3: 2024/03/12-15，**IOP4:** 2024/03/26-28

Aerosonde system



7 Sounding + 3 UAV positions



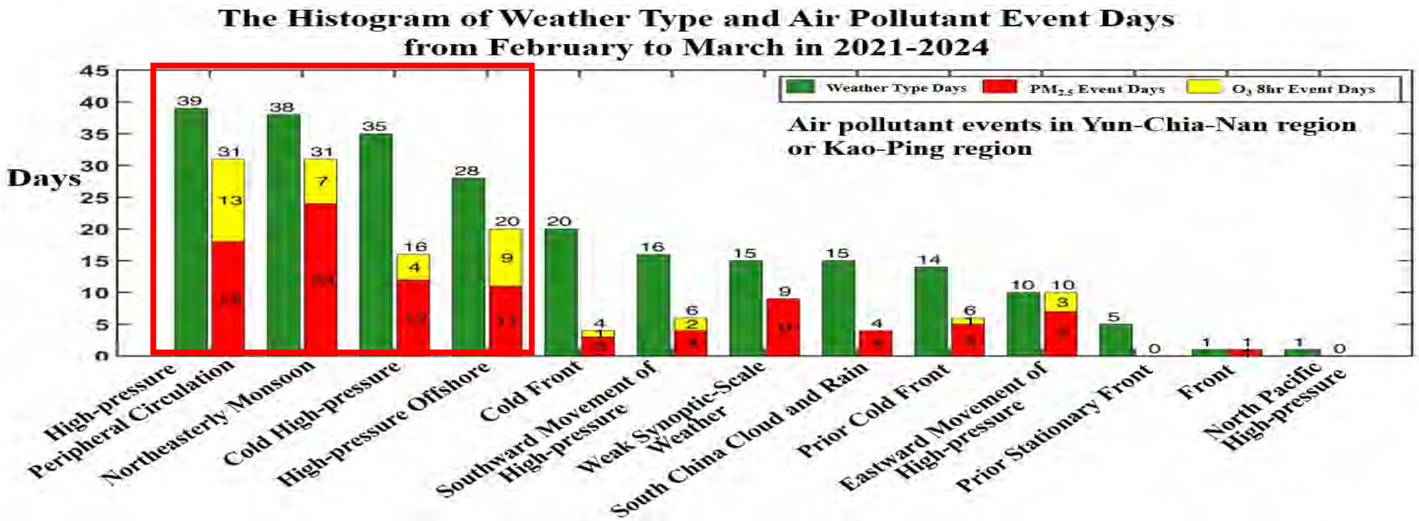


Hundreds of person-times

Synoptic Weather and Air Quality during KPEx




- The **Winter** and **Spring** are the worse air quality seasons in Taiwan.
- It is LUCKY for the **FOUR IOPs**, fit the weather patterns during **KPEx**.
- Great opportunity to understand the **vertical atmospheric structure** related to high pollution events.



IOP 1 02/15

High-Pressure Peripheral Circulation (HPPC)

Air pollution event Probability：80 %

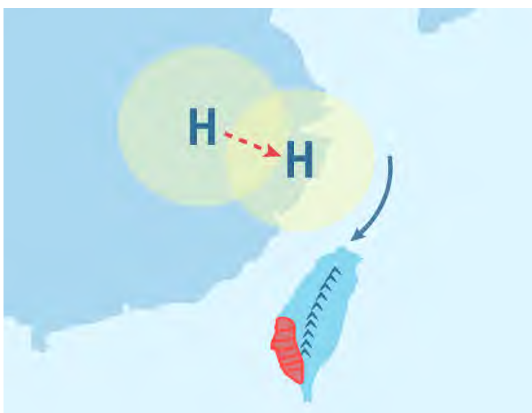
IOP 2 02/27

Northeasterly Monsoon → Cold High-Pressure

Air pollution event Probability：45~80 %

IOP 3 03/13

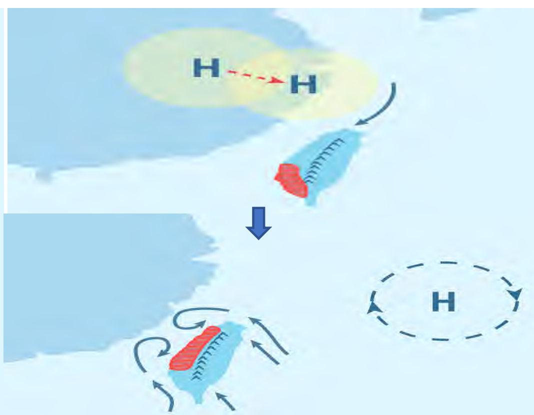
High-Pressure Offshore



Air pollution event Probability：70 %

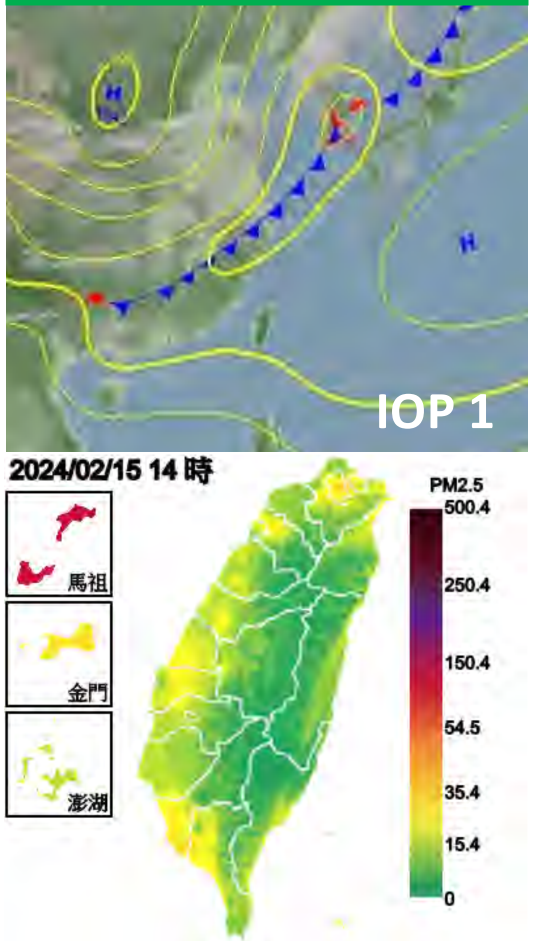
IOP 4 03/27

High-Pressure Offshore → HPPC



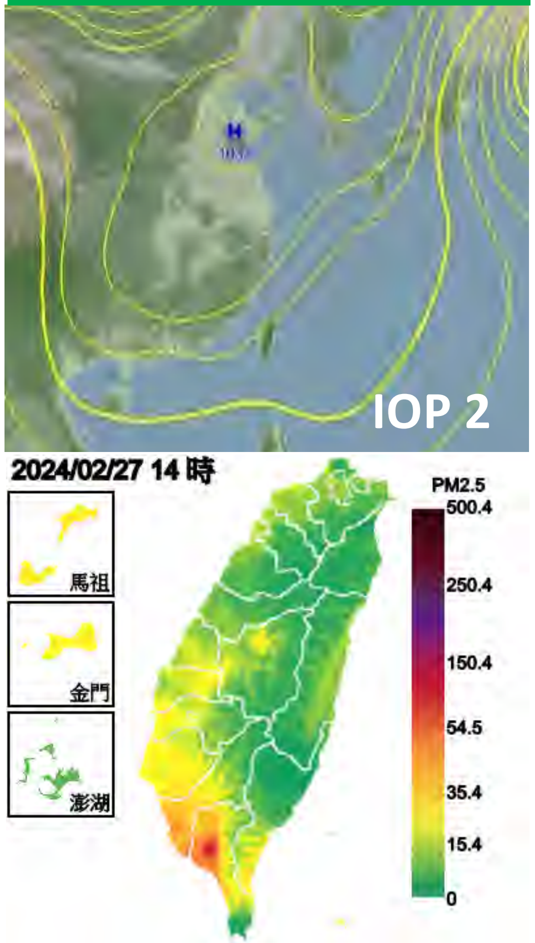
Air pollution event Probability：70~80 %

Pacific high pressure with an eastward moving cold front



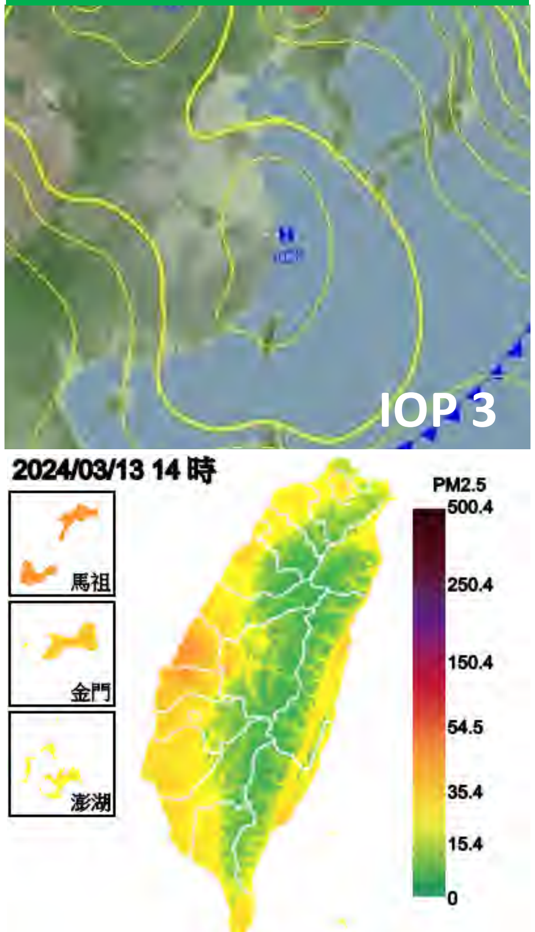
5th day of Rural New Year vacation, emission was low.

Continental high pressure with NE prevailing wind



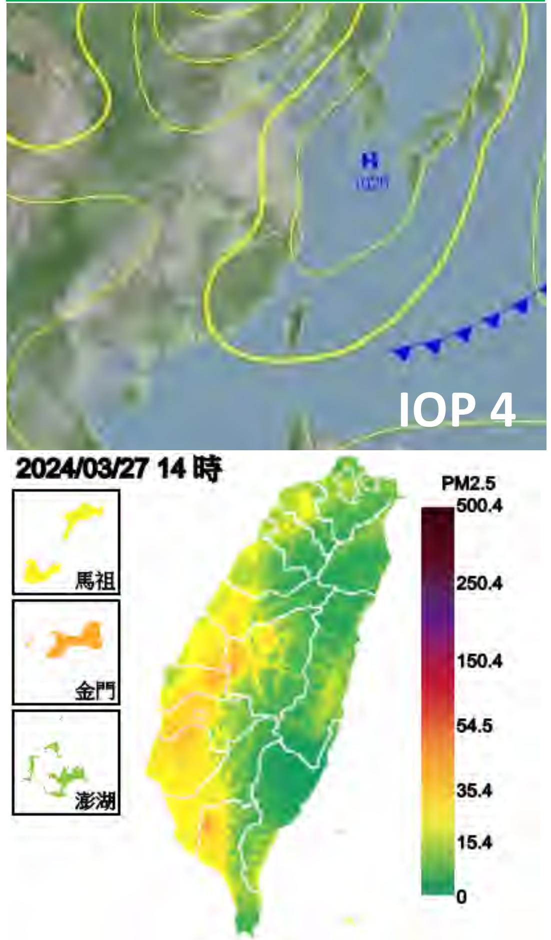
High polluted in the KP, compared with the other areas .

High-pressure system from Shanghai moving offshore



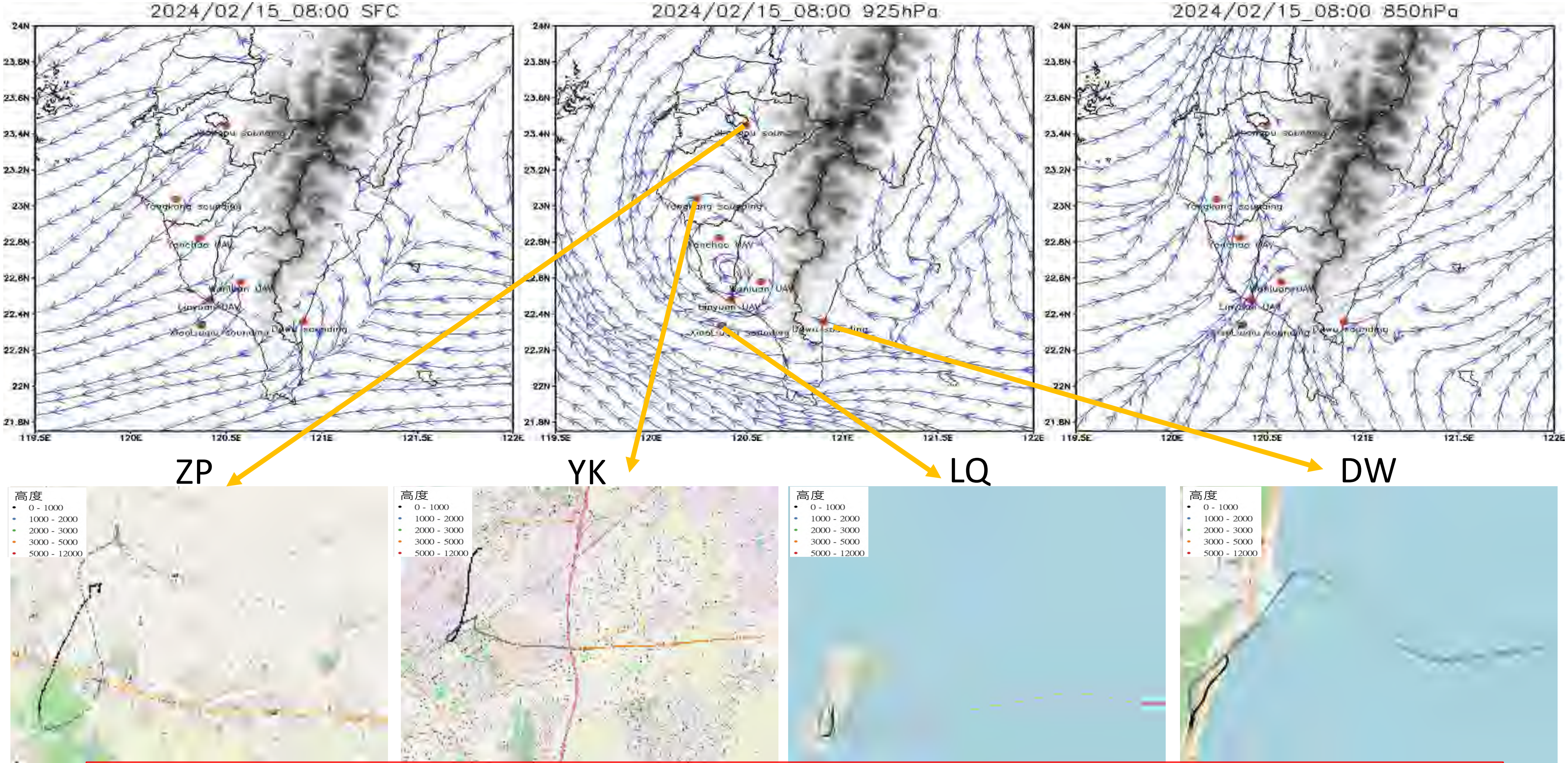
Long Range Transport dominated, whole Taiwan was under higher polluted.

High-pressure system moved eastward offshore



During High Pressure System movement, polluted areas were local specified.

Flow and Boundary Analysis



Analysis applied both of the WRF modeling and sounding observation, the comparison shown that they are quite consistent with each other.

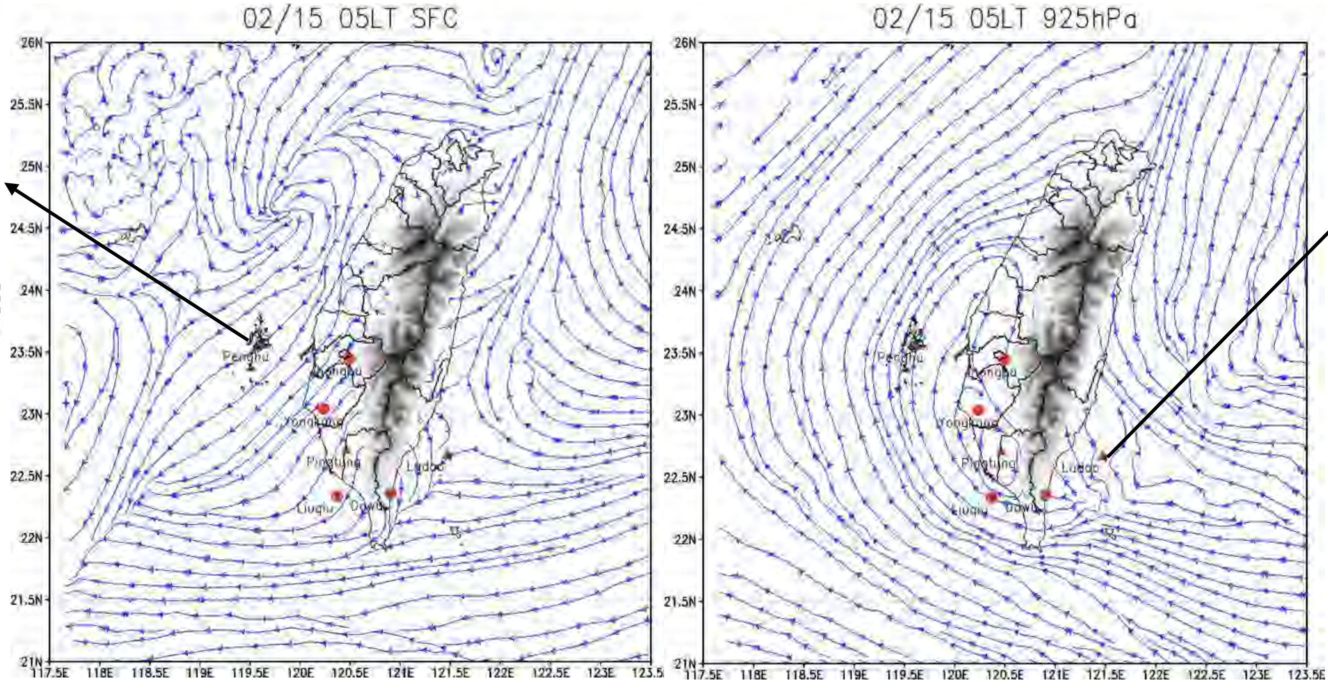
Analysis of synoptic to local patterns IOP 1

Magong

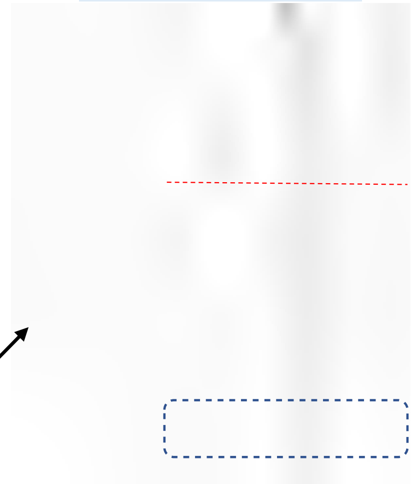
Synoptic - Regional

Flow - wind speed is weak, **obvious stratified, lee-side vortex**

Boundary Layers – 500~2000 m



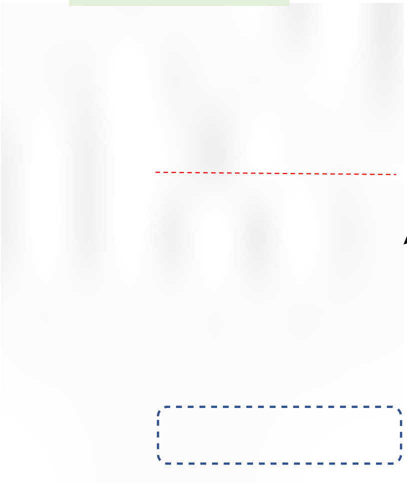
Green Island



Analysis of synoptic to local patterns IOP 1

Magong

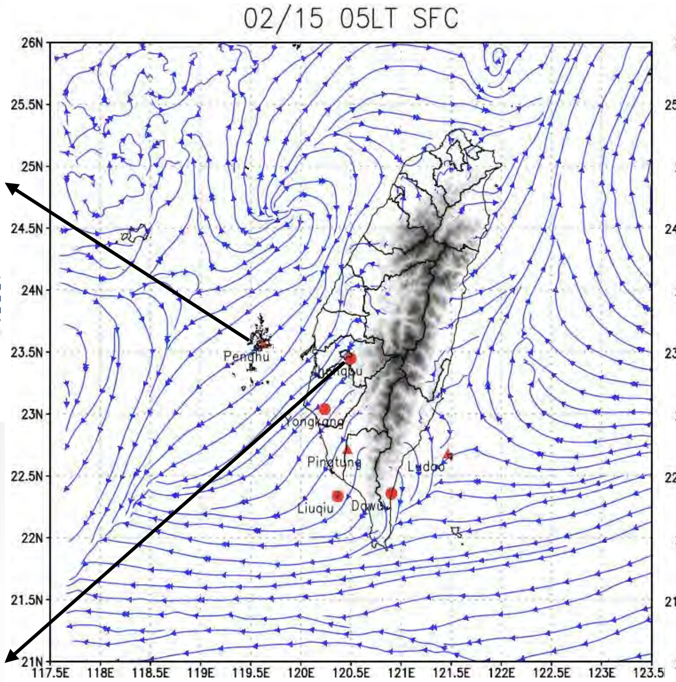
Zhongpu

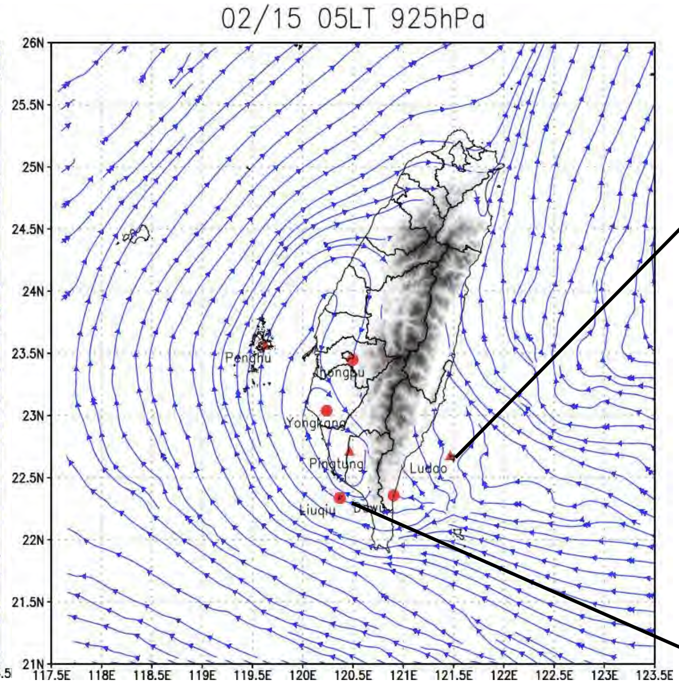


Synoptic to Regional

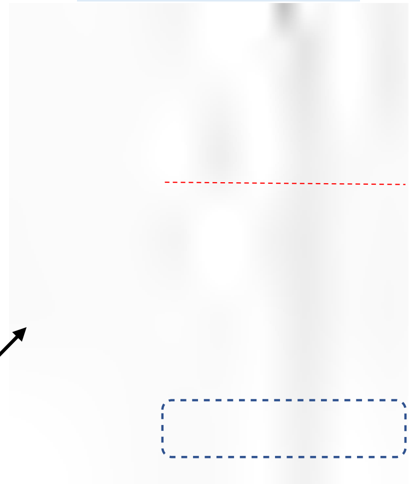
Flow - wind speed is weak, **obvious stratified, lee-side vortex**

Boundary Layers – 500~2000 m

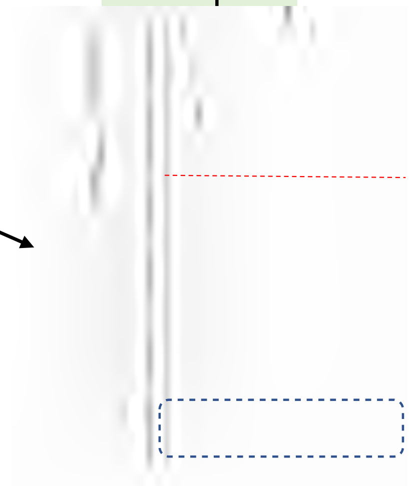




Green Island



Liuqiu



Regional - Local (Local Circulation)

Flow – **Obvious diurnal variation**, inland lee-side vortex

Boundary Layers – similar but smoother than regional

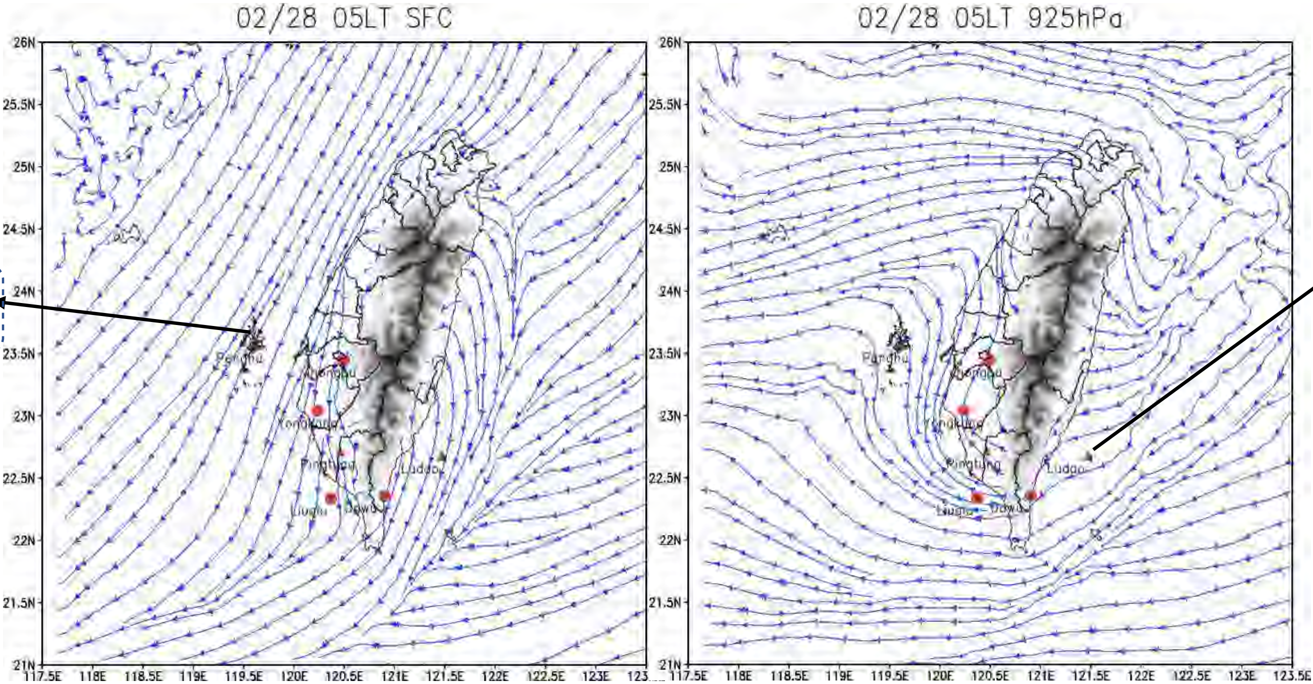
Analysis of synoptic to local patterns IOP 2

Magong

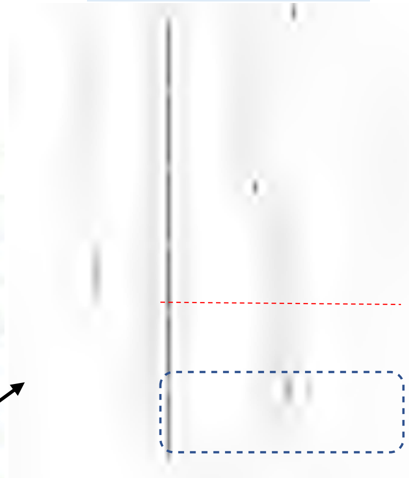
Synoptic - Regional

Flow – complex in vertical, NE-E-W, **obvious stratified**

Boundary Layers – lower~500m, multi-inversion



Green Island



Analysis of synoptic to local patterns IOP 2

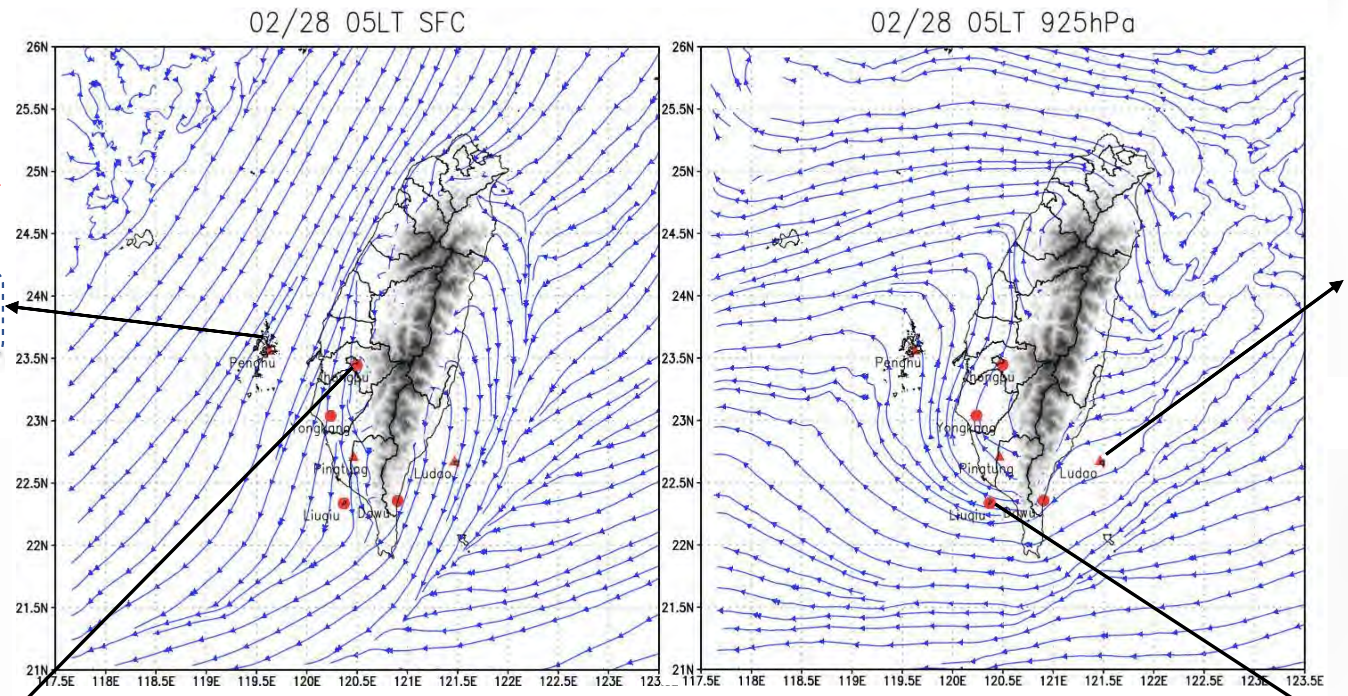
Magong

Zhongpu

Synoptic - Regional

Flow – complex in vertical, NE-E-W, **obvious stratified**

Boundary Layers – lower~500m, multi-inversion

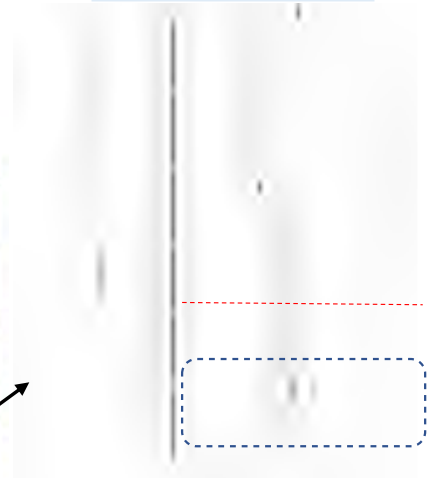


Regional - Local

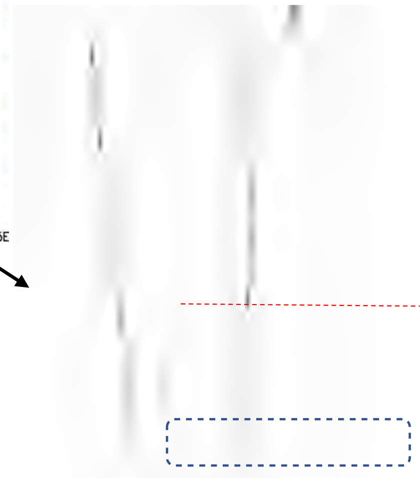
Flow – separate by CMR, **inland lee-side vortex**, also stratified

Boundary Layers – 200~1000 m

Green Island



Liuqiu



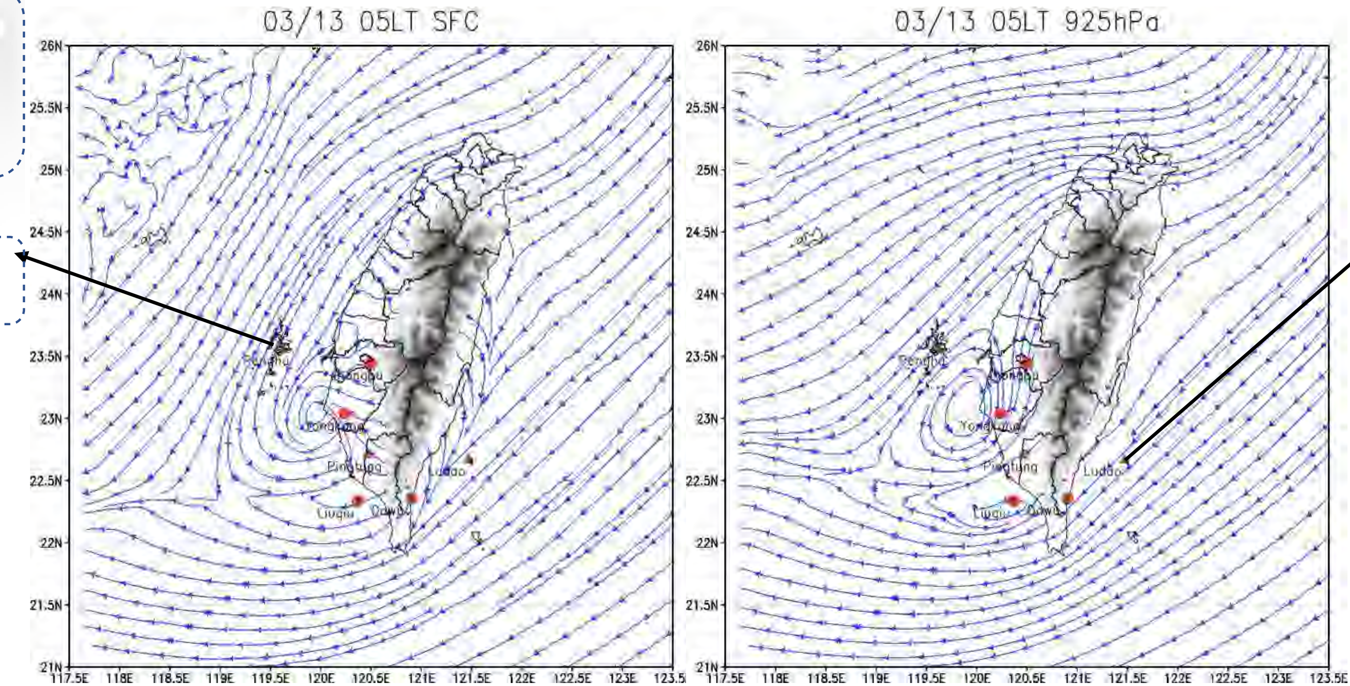
Analysis of synoptic to local patterns IOP 3

Magong

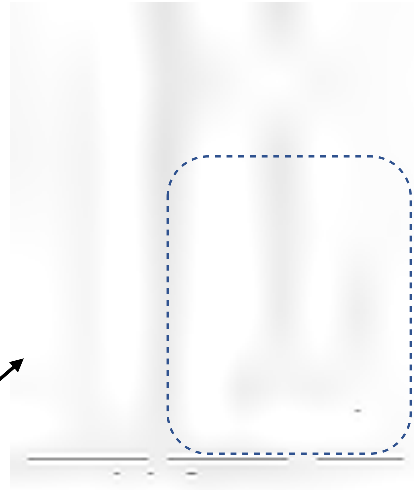
Synoptic to Regional

Flow – **Lee-side vortices** from SFC up to 850 hPa, **obvious stratified**

Boundary Layers – 500~1500 m



Green Island

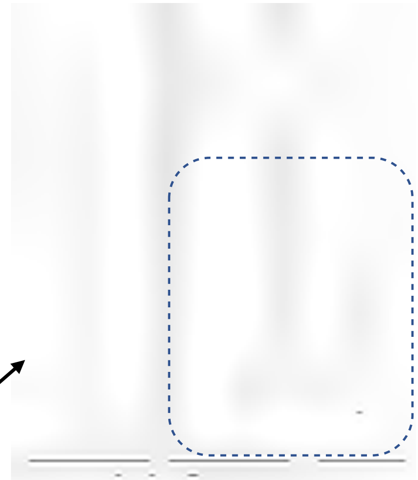


Analysis of synoptic to local patterns IOP 3

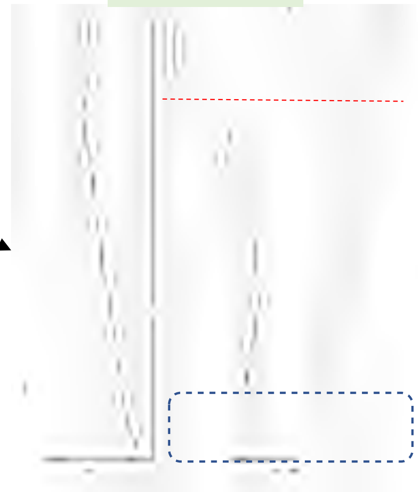
Magong

Zhongpu

Green Island



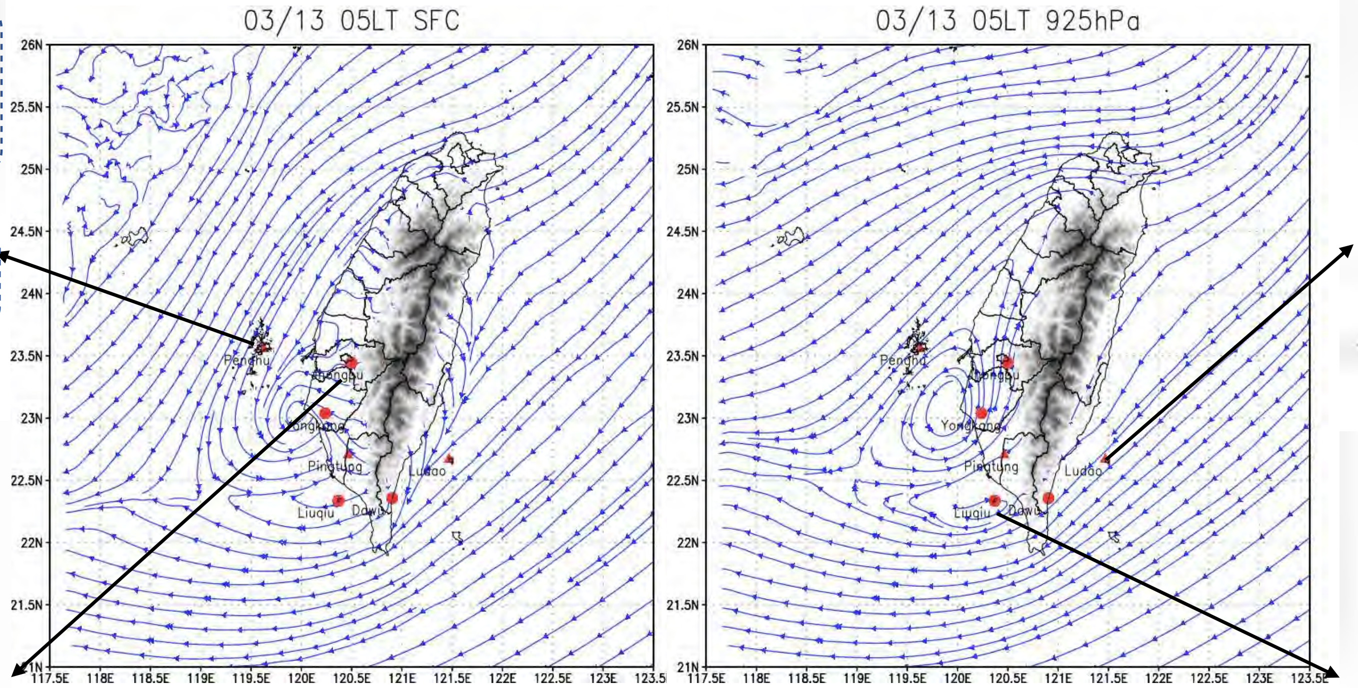
Liuqiu



Synoptic to Regional

Flow – **Lee-side vortices** from SFC up to 850 hPa, **obvious stratified**

Boundary Layers – 500~1500 m



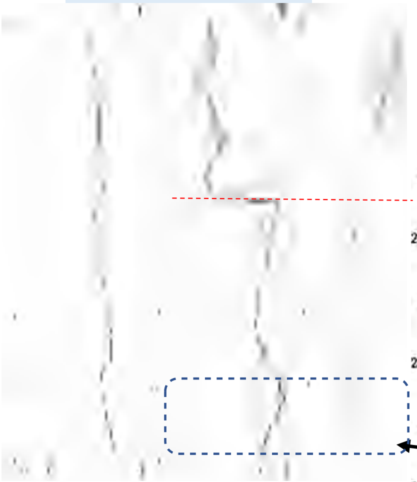
Local (Local Circulation)

Flow – NE to E, **Lee-side vortices**, wd shift in vertical

Boundary Layers – similar but smoother than regional

Analysis of synoptic to local patterns IOP4

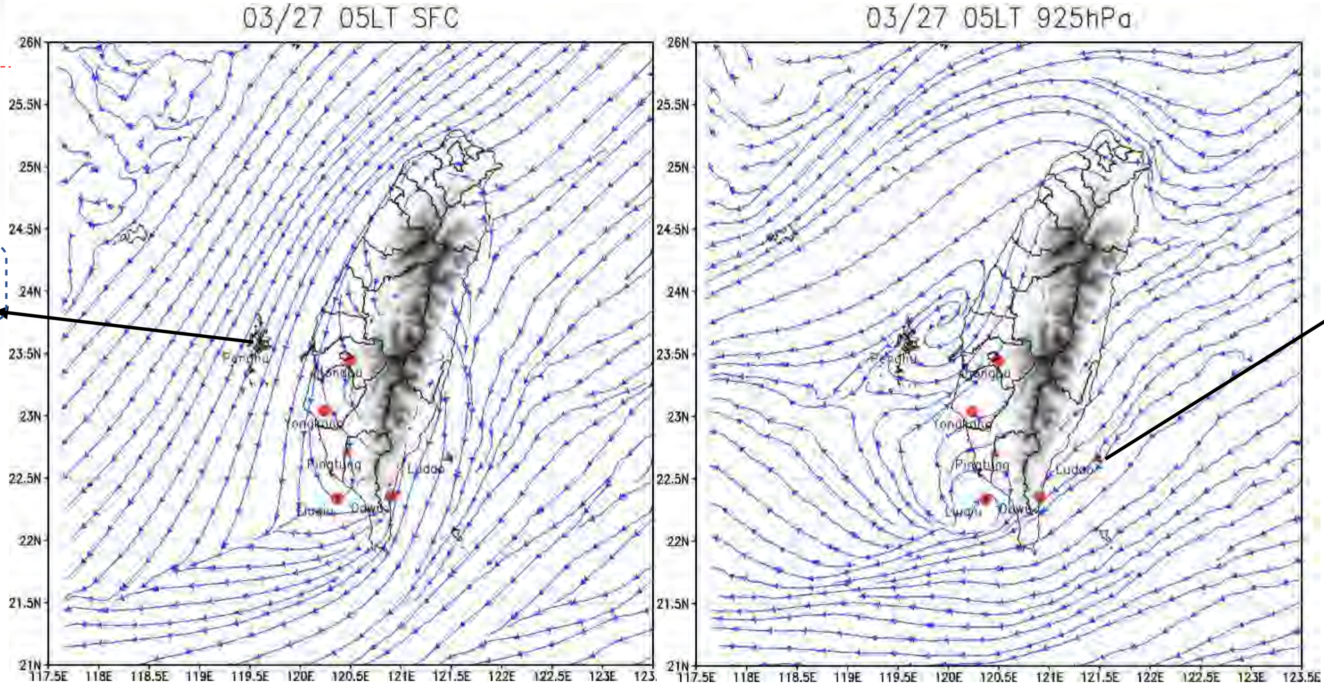
Magong



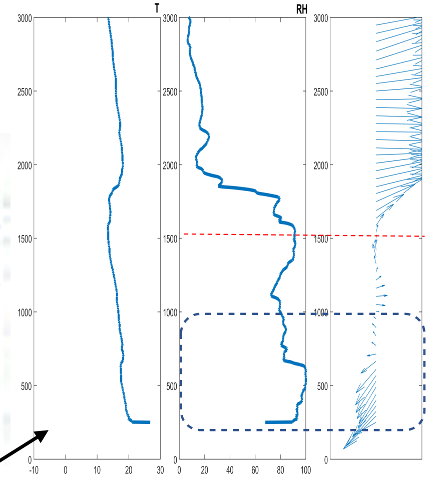
Synoptic to Regional

Flow – **obvious stratified, lee-side vortices**

Boundary Layers – 500~1500 m

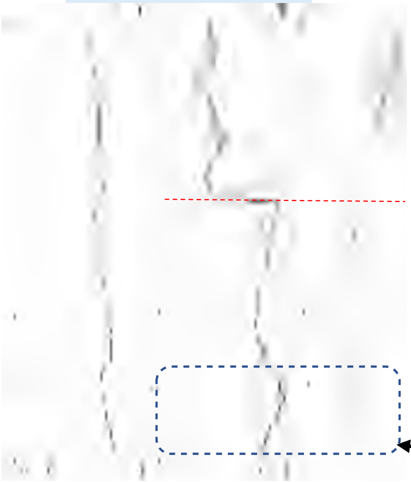


Green Island

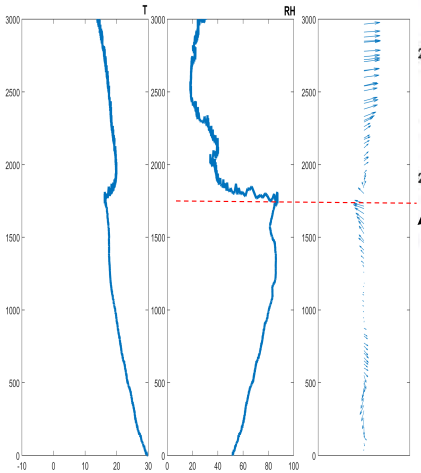


Analysis of synoptic to local patterns IOP4

Magong



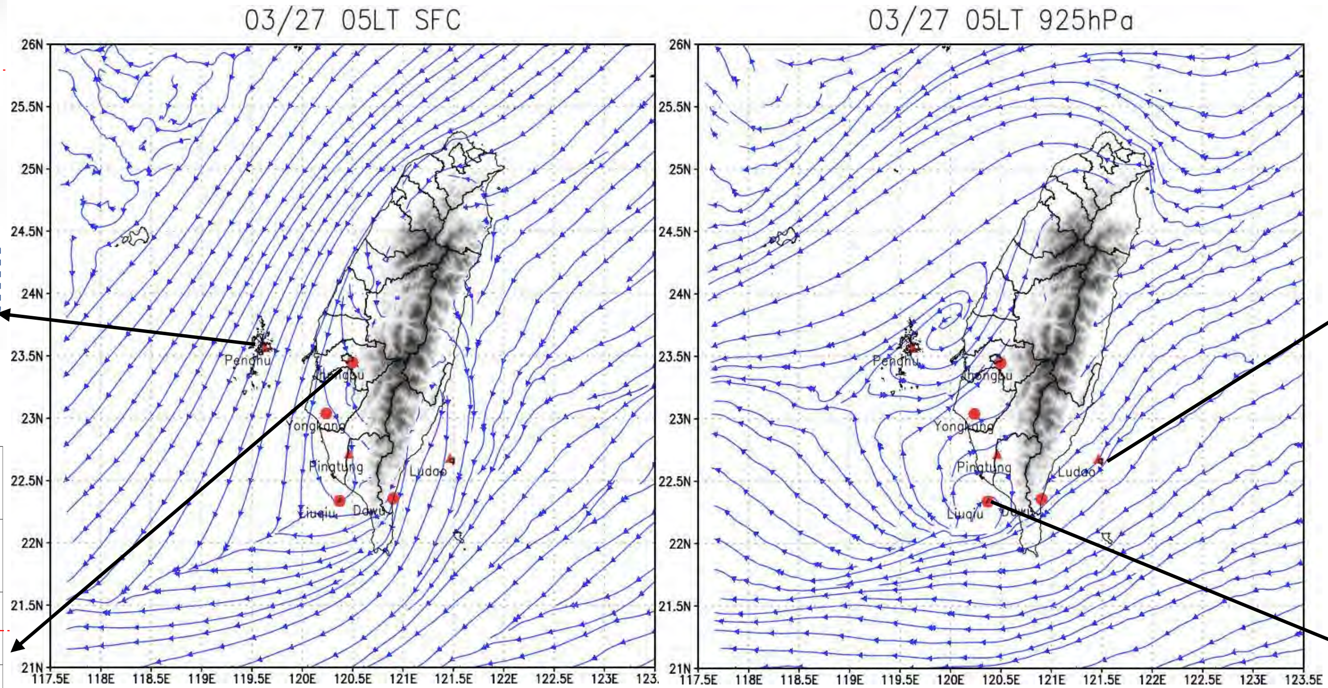
Zhongpu



Synoptic to Regional

Flow – **obvious stratified, lee-side vortices**

Boundary Layers – 500~1500 m

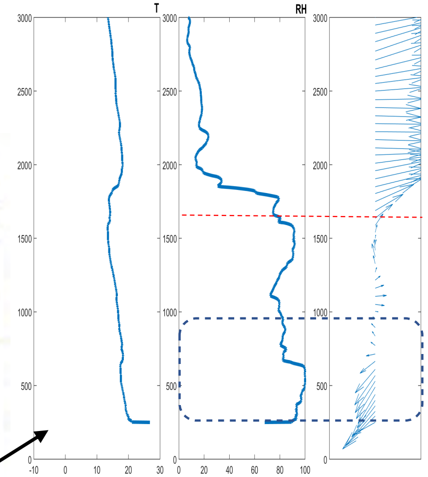


Regional - Local

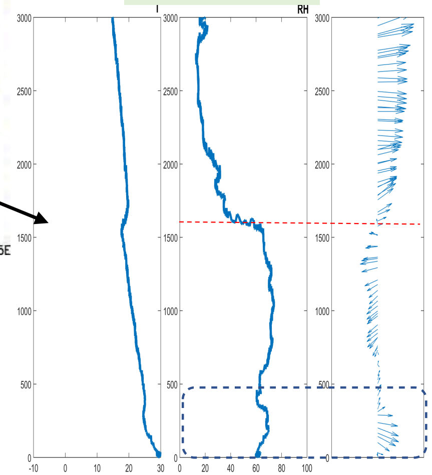
Flow – **Vortices** in upper layer, wd stratified

Boundary Layers – similar with regional

Green Island



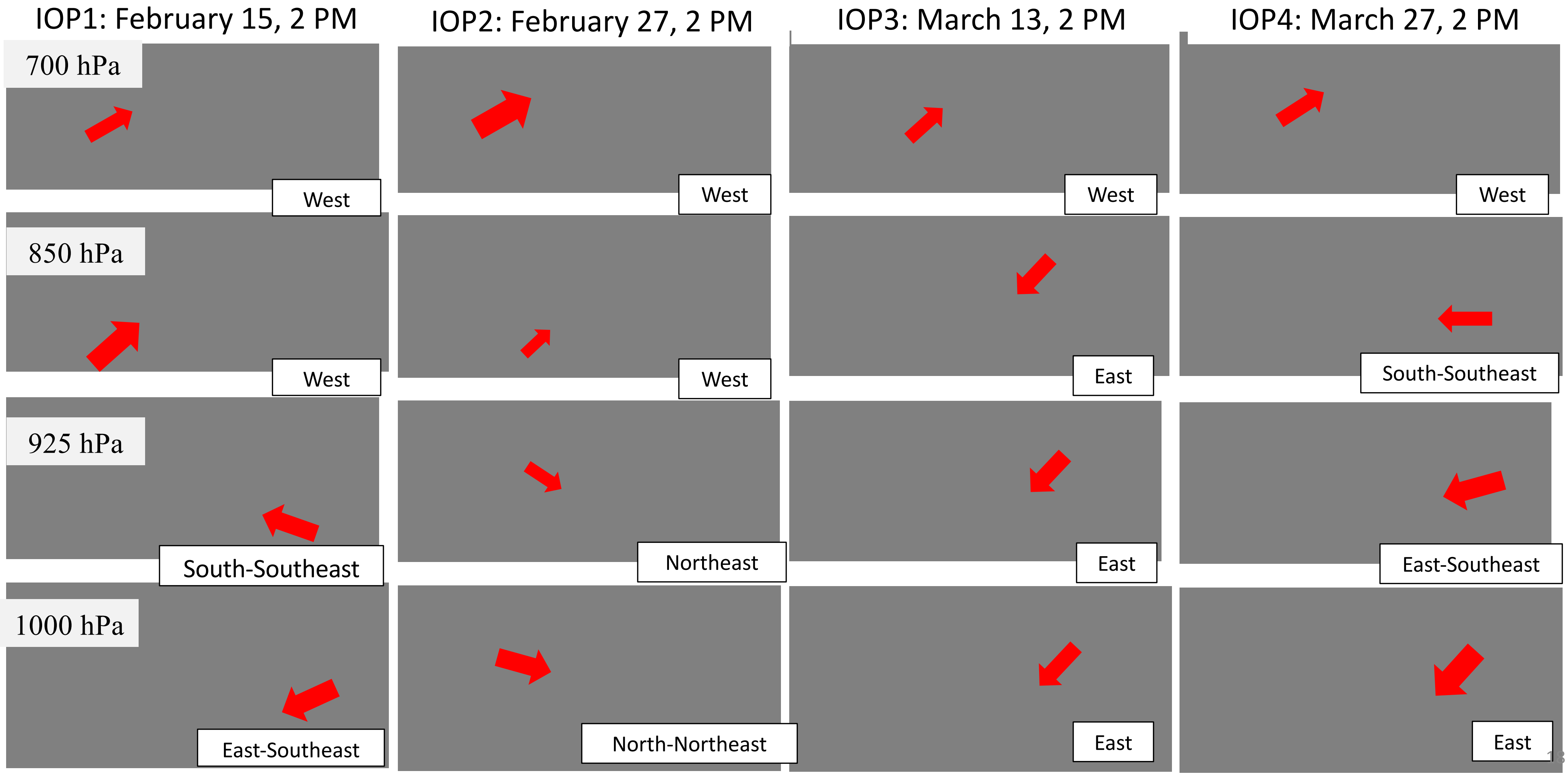
Liuqiu



Impact of Terrain on Vertical Structure of $PM_{2.5}$ and Air Flow




Interaction of Environmental Wind Fields with Terrain Effects is a key issue for air quality in Southern Taiwan.

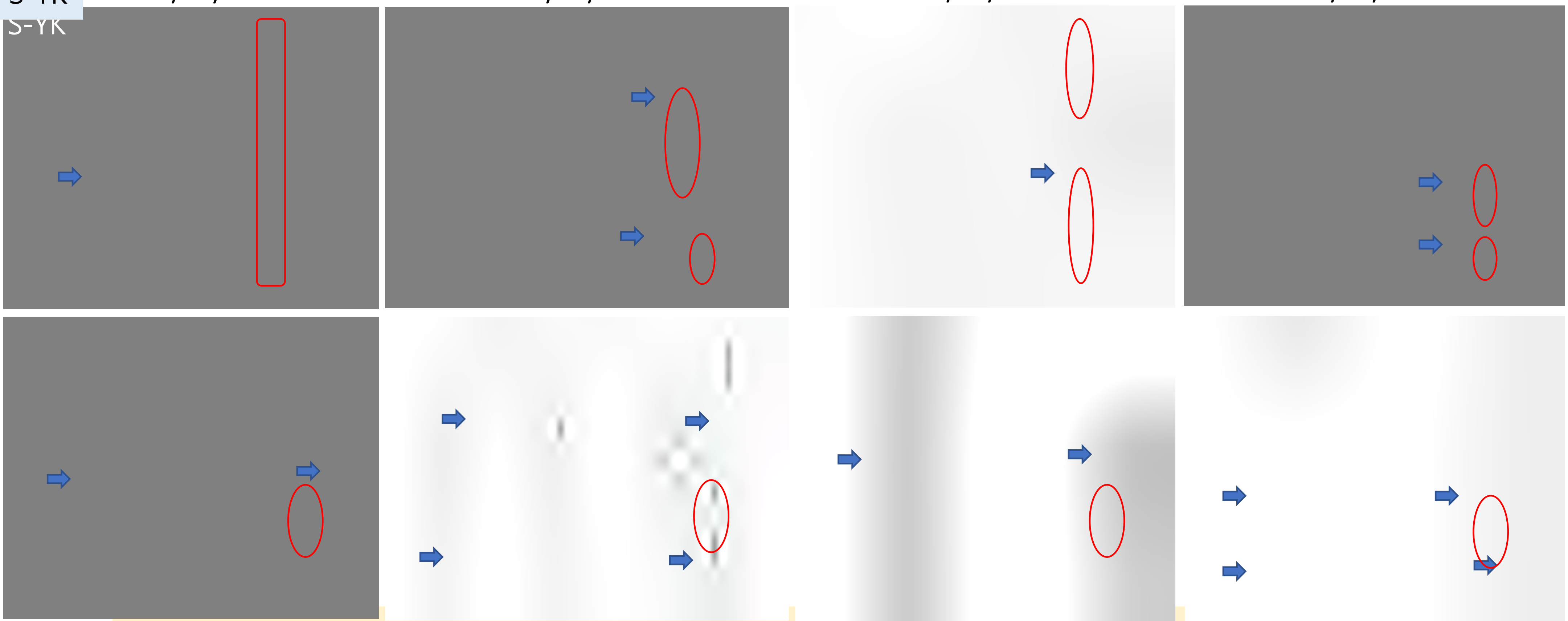


IOP 1 S-YK 2024/02/15 11:00

IOP 2 2024/02/28 11:00

IOP 3 2024/03/13 11:00

IOP 4 2024/03/27 11:00

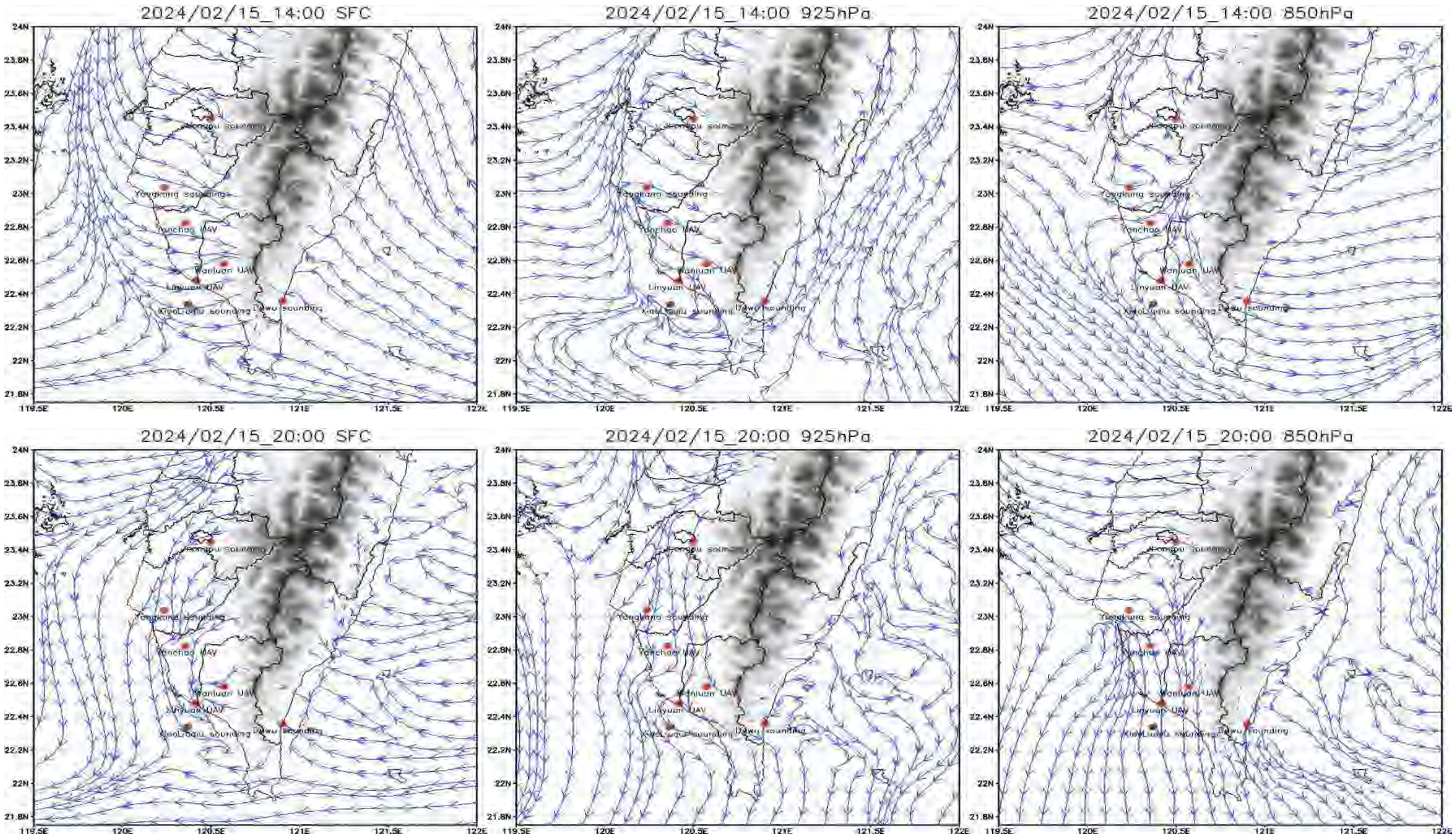


- Sounding observations indicate that air pollutants often exist at higher altitudes (above 2000 m) in case.
- Frequently, there is a southern wind layer existed in 500-1500 m height cause by splitting flow from east.

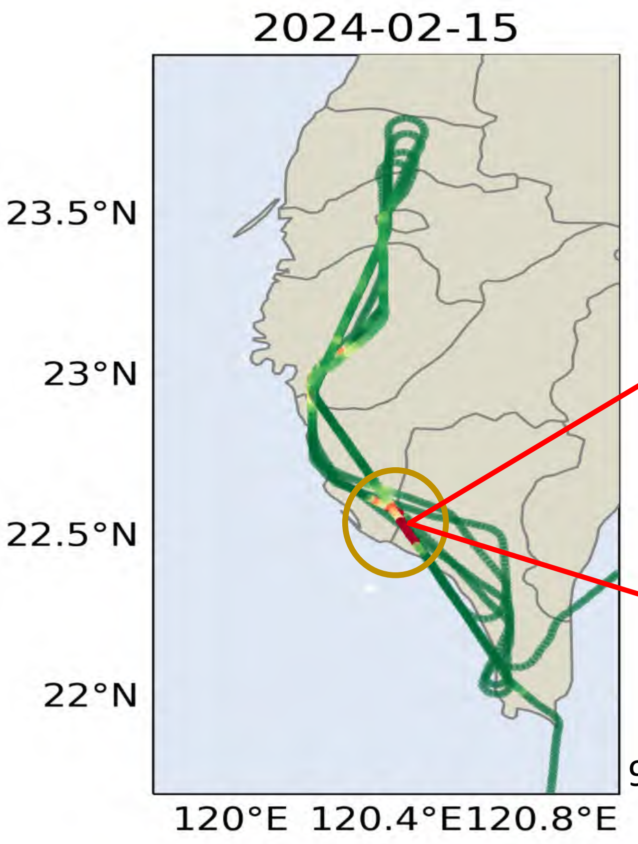
Interesting Patterns related Terrain Effect



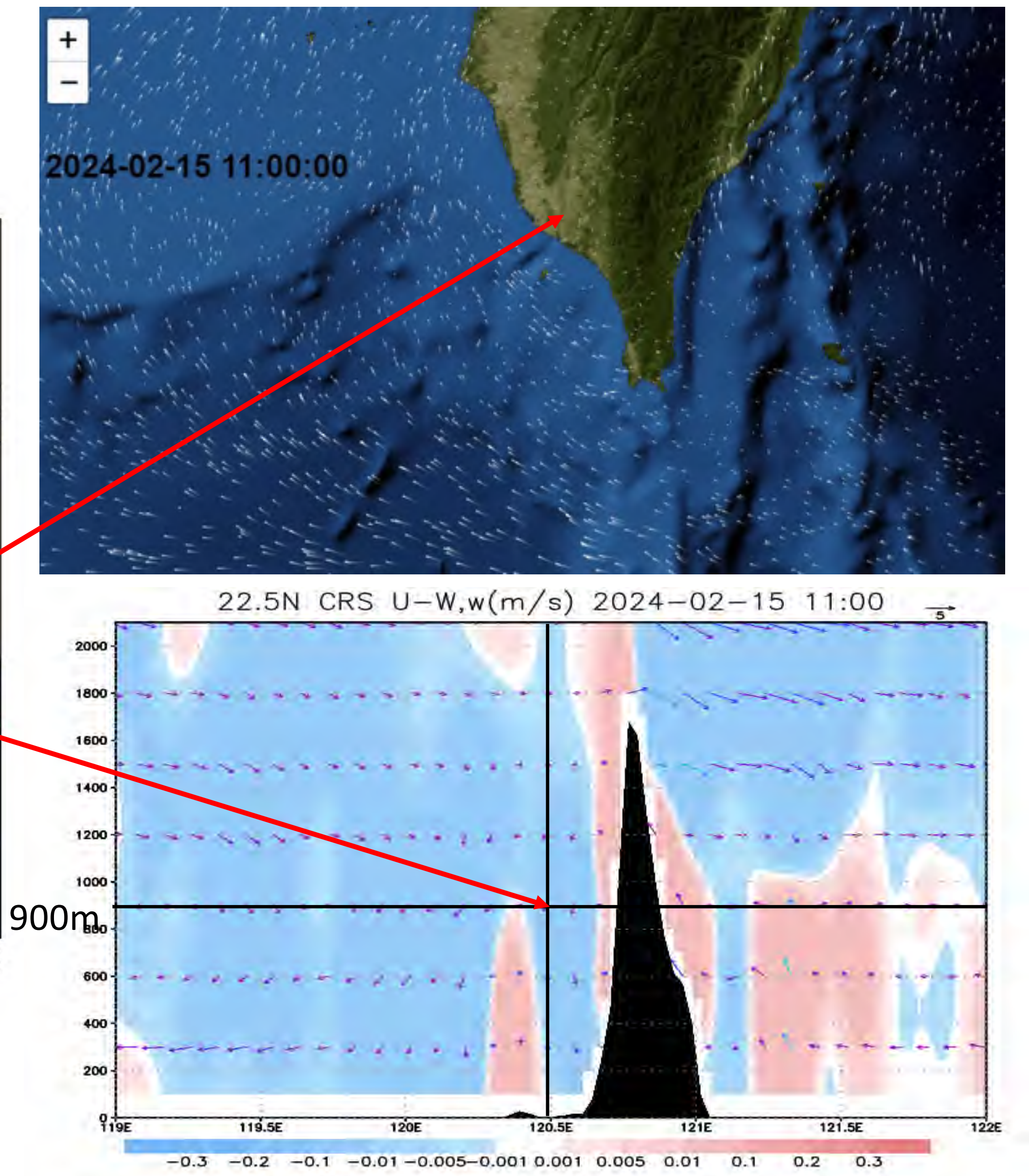

The sounding trajectories and model flow fields show that the local circulation phenomenon during IOP1 is quite significant.



S-YK Trajectory

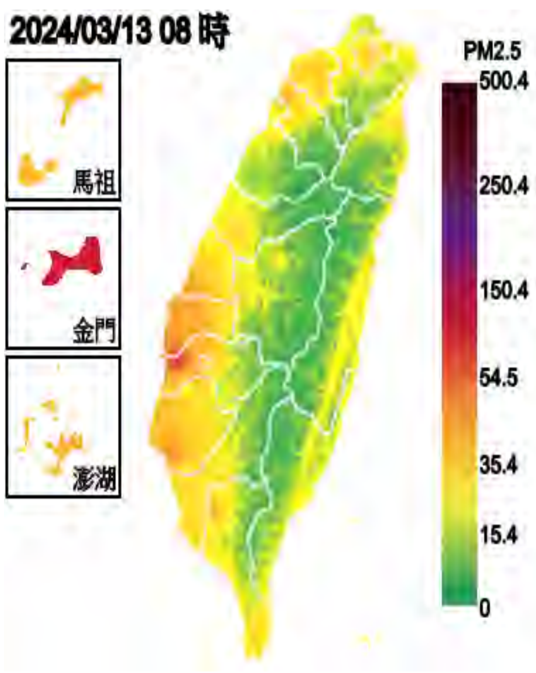


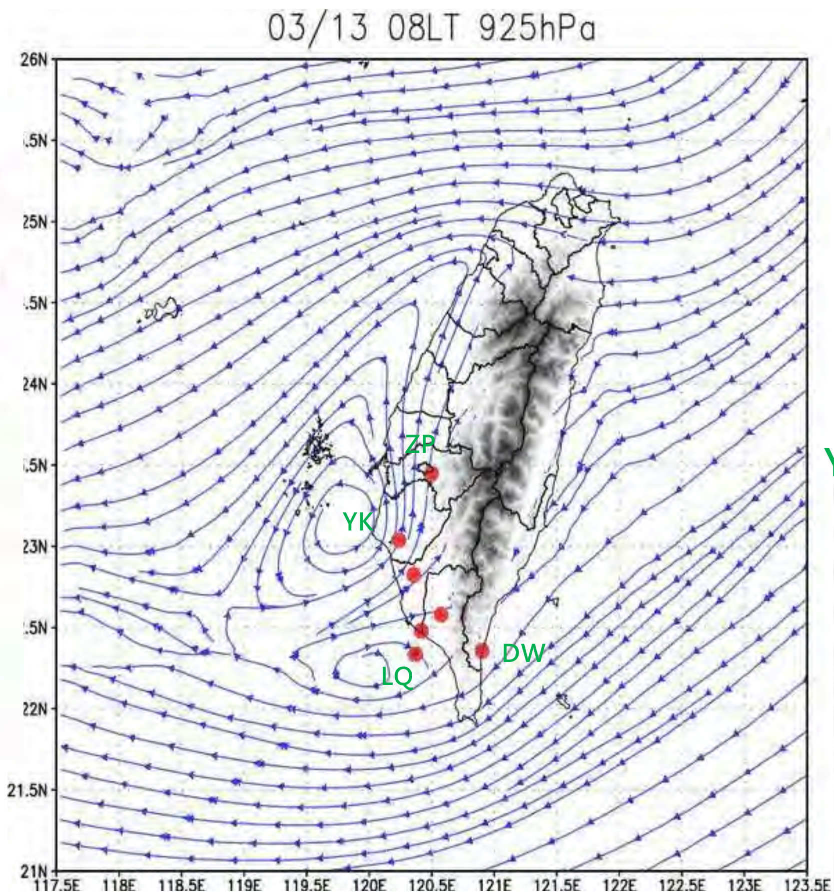
NASA DC-8 track and
NO2 measurement

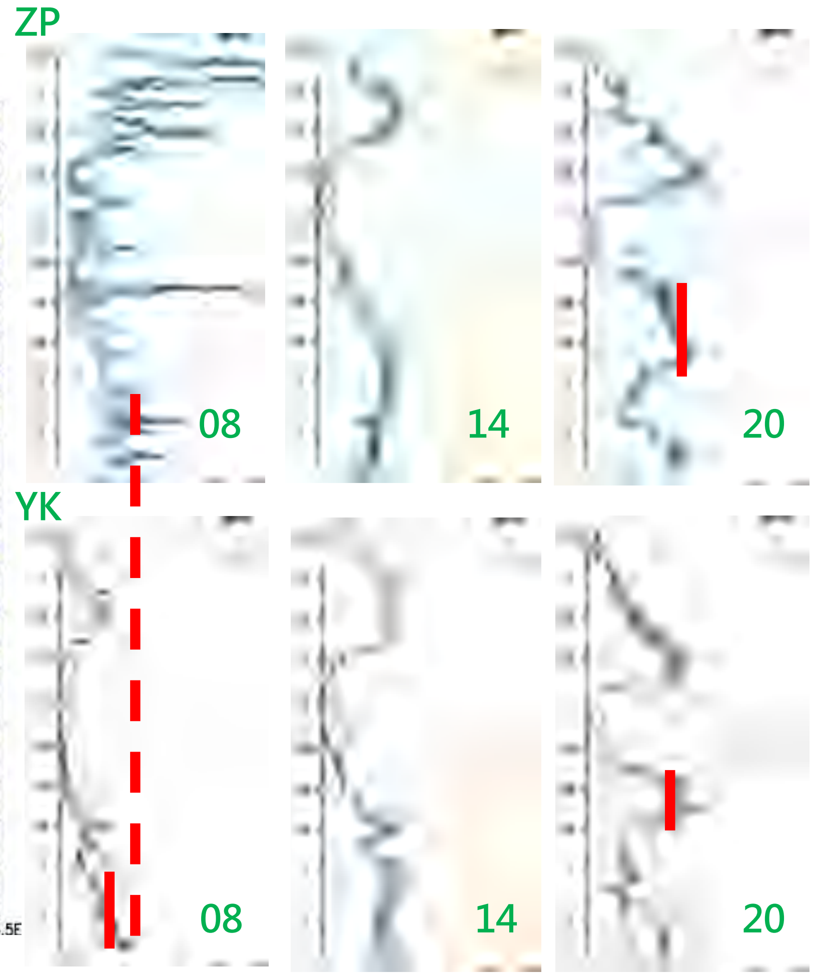


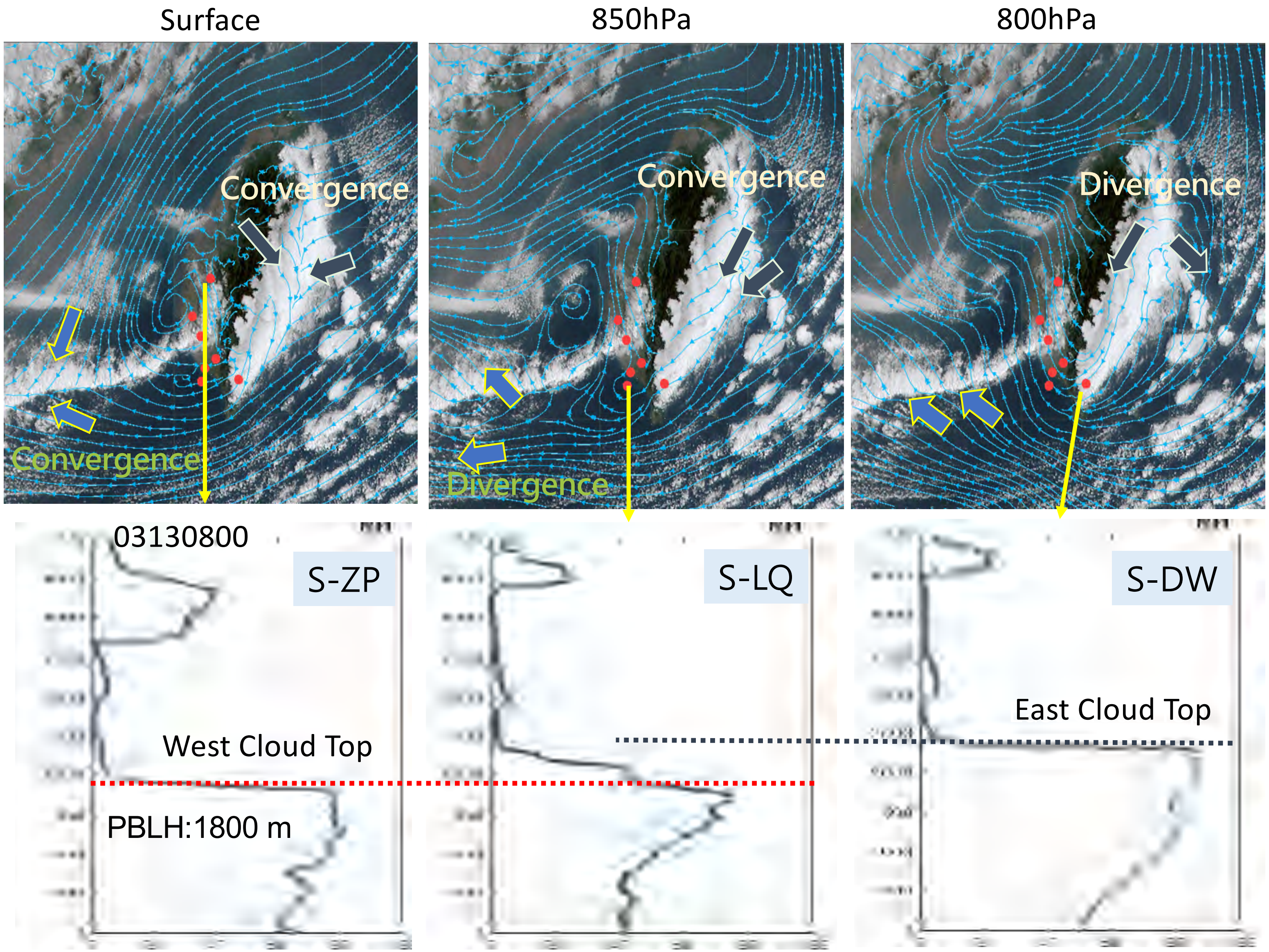
- During IOP1, the DC-8 measured high NO_2 concentrations at 900m height near the Kao-Ping boundary.
- The position of high NO_2 concentration is located in the center of lee-side vortex with clockwise motion in horizontal and downward in vertical.

- On March 13, elevated $PM_{2.5}$ levels were observed in the Changhua-Yunlin-Chiayi area.
- Soundings and models detected leeside vortex phenomena.
- WRF model analysis confirmed alignment between pollutant accumulation and vortex positions.





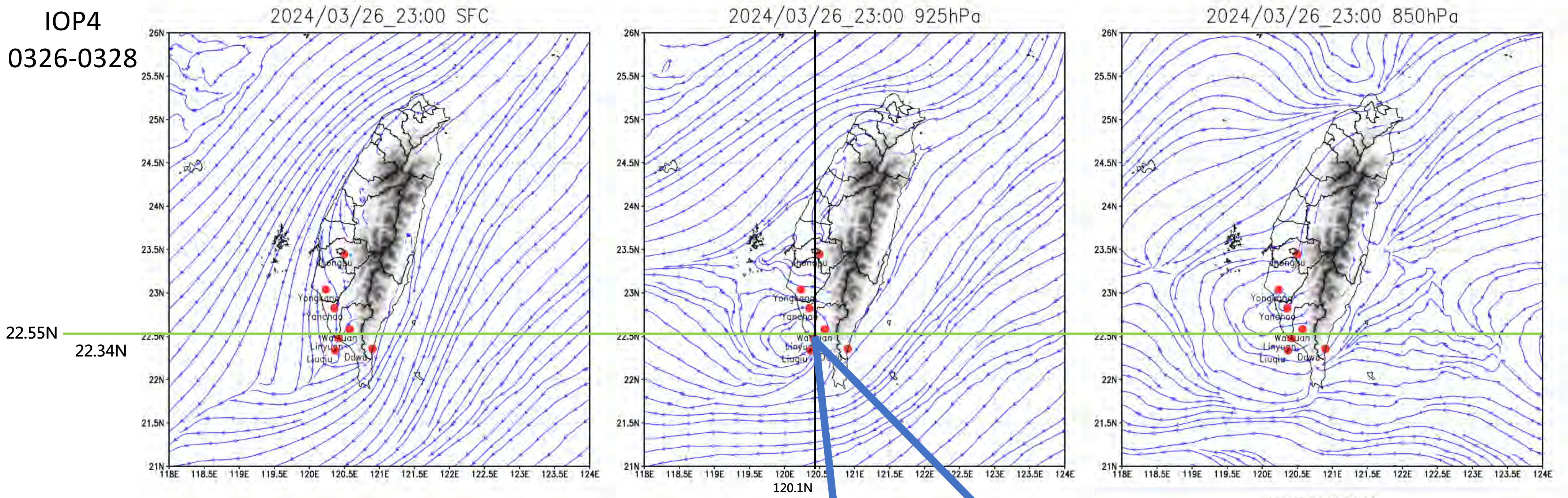




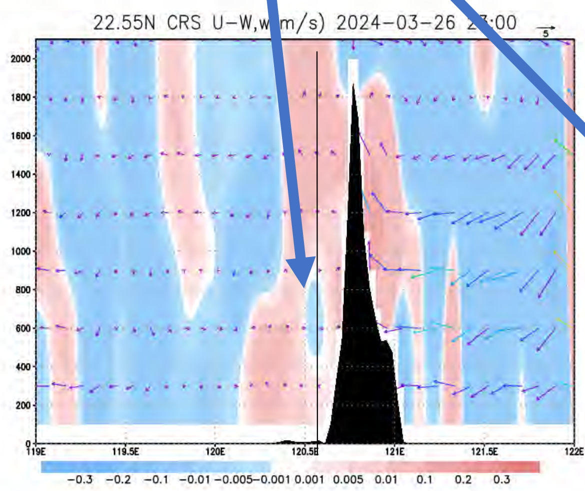
Not only can we address the air quality issue, but we can also understand the cloud mechanism from KPEx. Combined with atmospheric model flow, sounding data, and satellite images, it is clear to identify the convergence and divergence associated with cloud top on both the west and east sides of Taiwan.

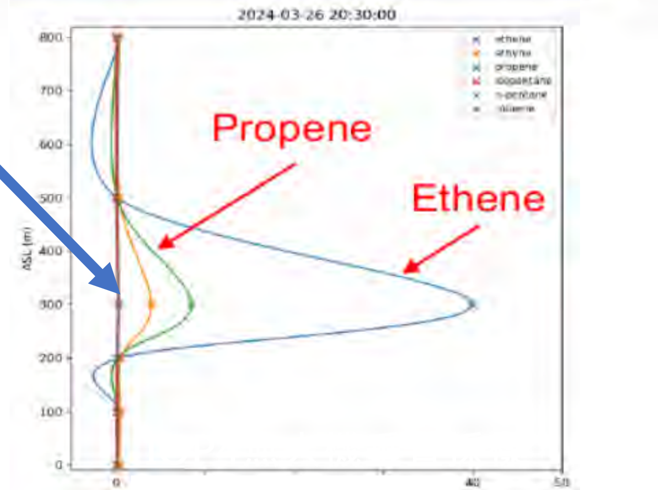
IOP 3 : 2024/03/13 08:00

IOP4
0326-0328



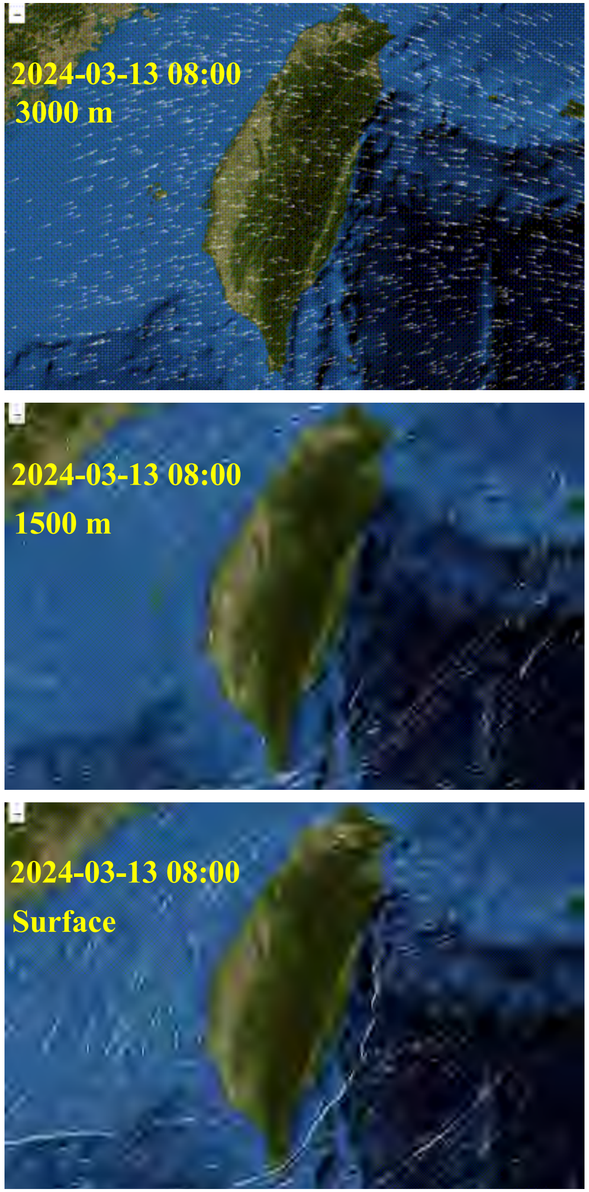
According to the UAV observation in Linyuen, an ethene peak 40ppb was found at 300m height, it shown that there was a vortex center in the same location and height.

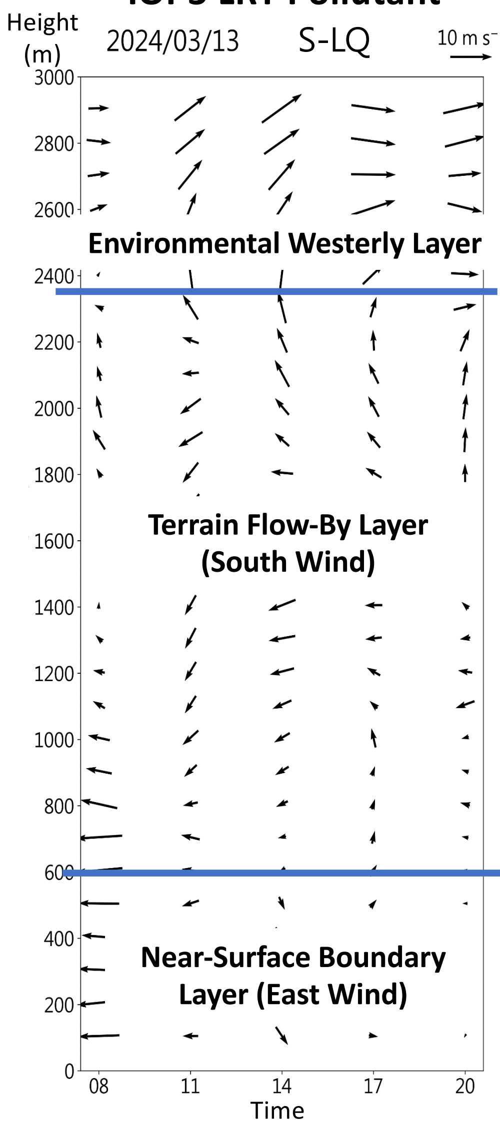




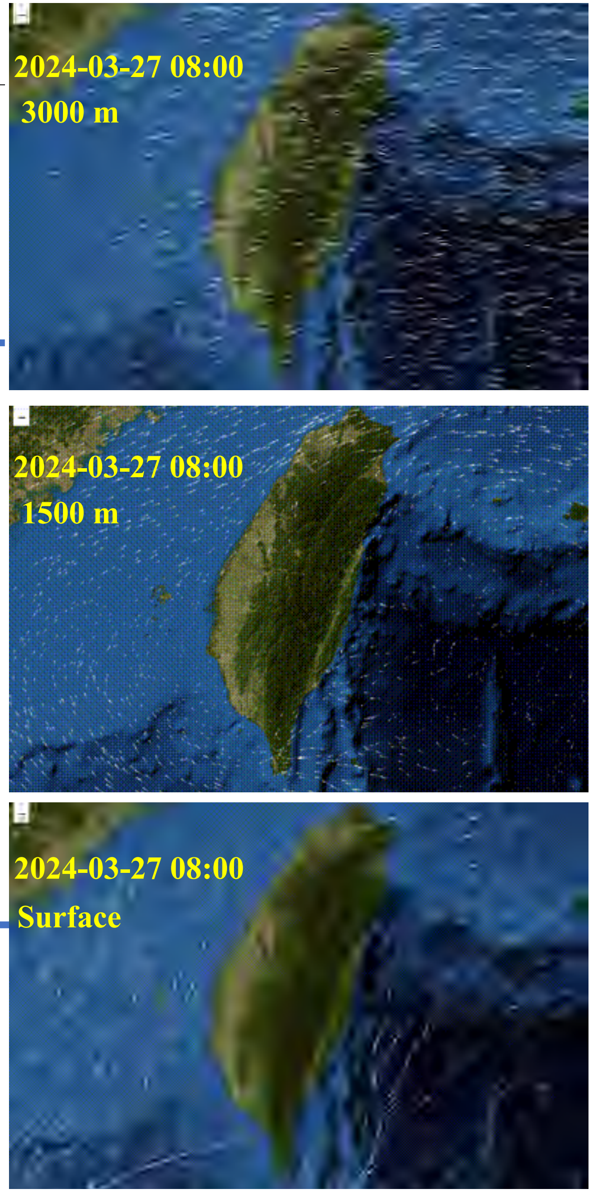
From CL Wang et al.

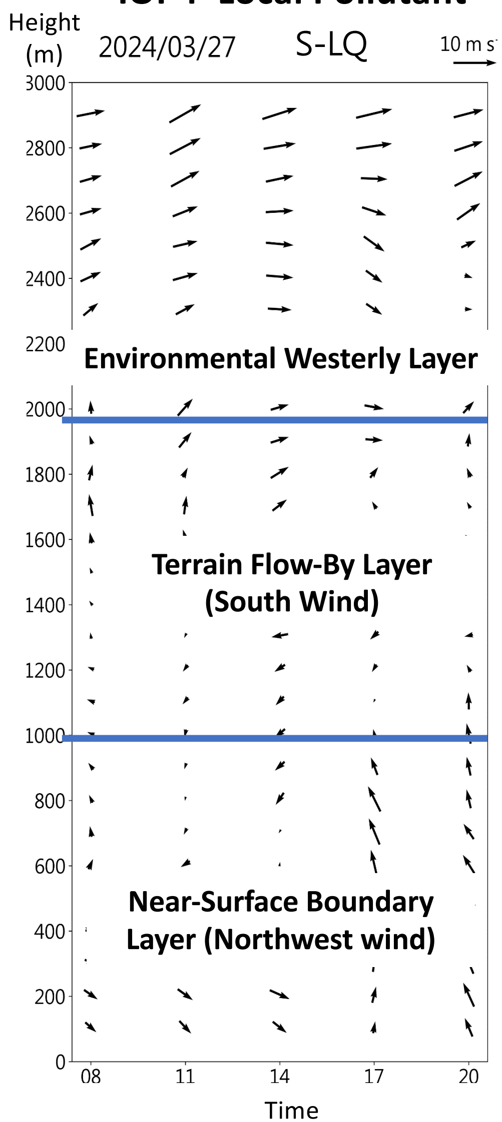
IOP3 LRT Pollutant





IOP4 Local Pollutant





Conclusion

Weather Patterns

- Weather systems during IOPs provide “suitable” background for air pollution events.
- Synoptic flow Interact with terrain is proved by observation.

Terrain Effects

- Interaction between topography and vertical wind fields is critical for air quality.
- Lee-side vortices

Dispersion

Transport

Vertical Stratification

- Near-Surface Boundary Layer
- Terrain Flow-By Layer
- Environmental Westerly Layer

Complex and difficult, but we are working on …

ASIA-AQ Workshop

Numerical Study Boundary Layer Circulations Impact on Air Pollutants Formation and Transportation during KPEx IOP#3 over Southwestern Taiwan

Chuan-Yao Lin,

KPEx and ASIA-AQ Research Teams

環境變遷研究中心

空氣品質專題中心

Air Quality Research Center, RCEC

Overview: Air quality and ambient wind

O3 (21 stations)

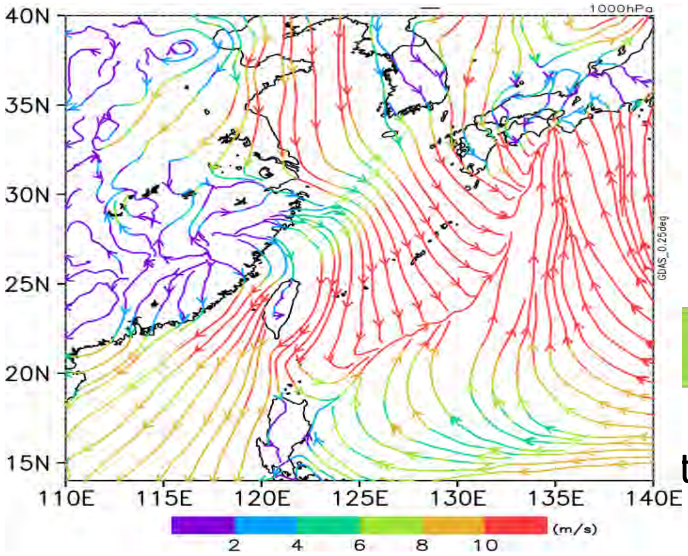
O3 (36 stations)

PM2.5 (5 stations)

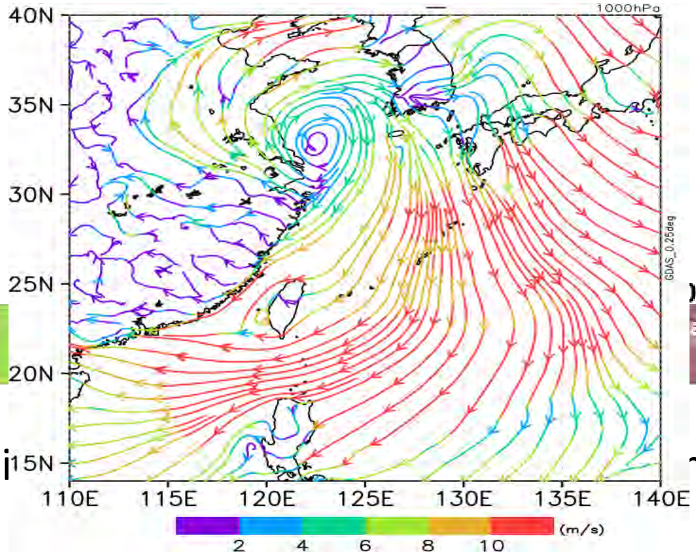
O3 (13 stations)

PM2.5 (18 stations)

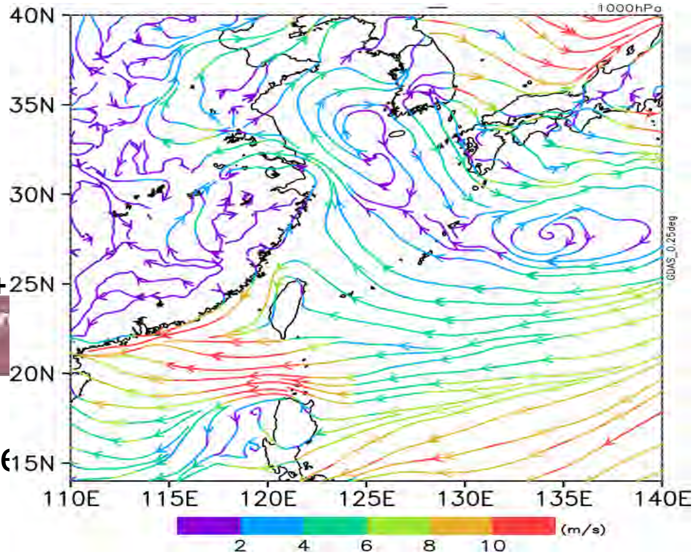
March 12



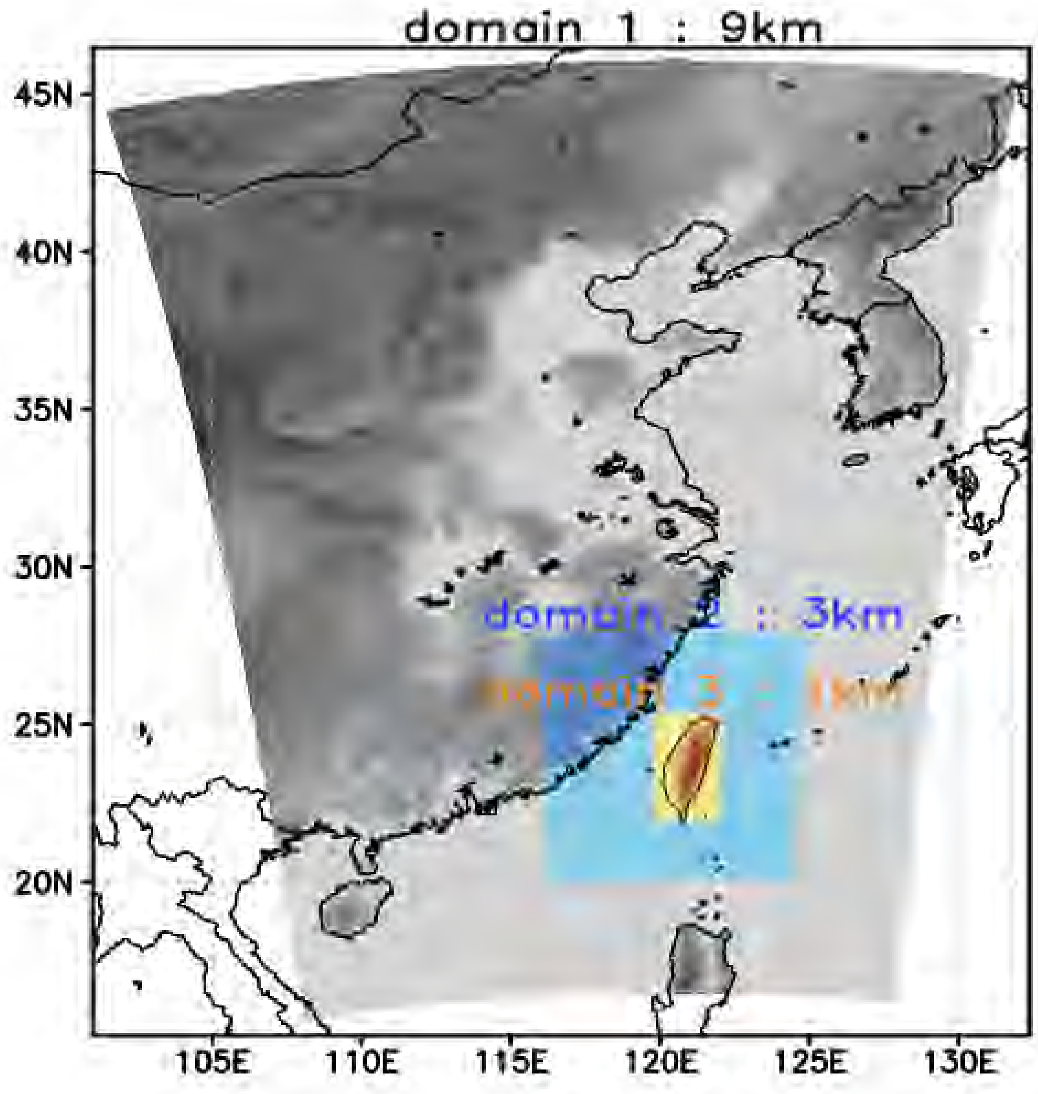
March 13



March 14



Model and observation data sources

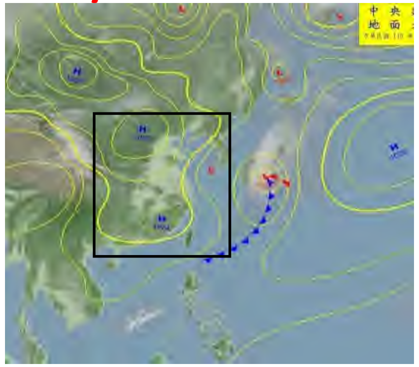


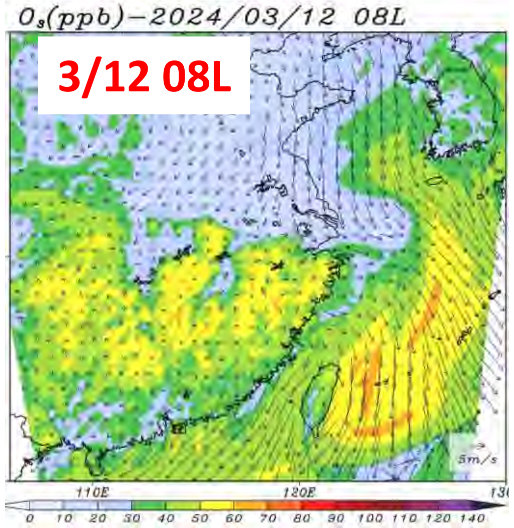
- **Model** : WRFChem 9/3/1 km :
  Met. IC.BC NCEP FNL(GDAS, 3-hour)
- **Emission sources**: Taiwan-TEDS 10.0 (2016)
  China- MISC Asia (2010)
- **Model configures:**

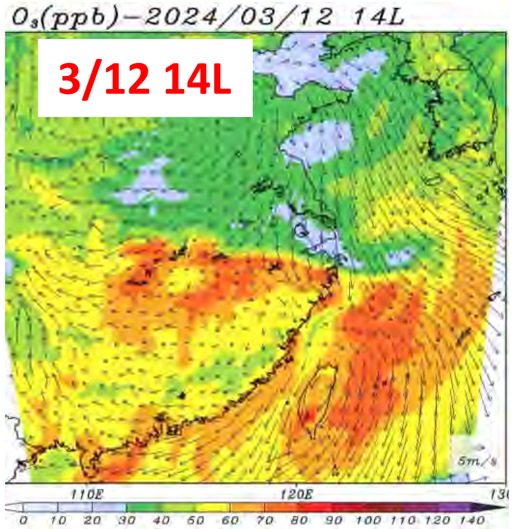
Microphysics : Lin et al.
Long-wave radiation : RRTMG
Short-wave radiation : RRTMG
Surface layer : Monin-Obukhov
Land-surface model : Unified Noah LSM
Boundary layer scheme : MYJ TKE scheme
Cumulus : Grell 3D ensemble scheme
Chemistry model : NOAA/ESRL RACM
Aerosol model : MADE/VBS aerosols use KPP library
Urban canopy model :Yes

Weather Conditions and Air Pollutants Transport during ASIA-AQ/KPEx IOP#3

3/12 08L

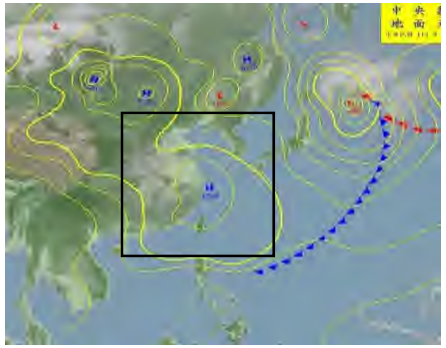




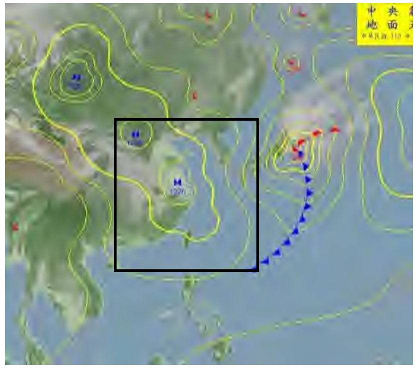


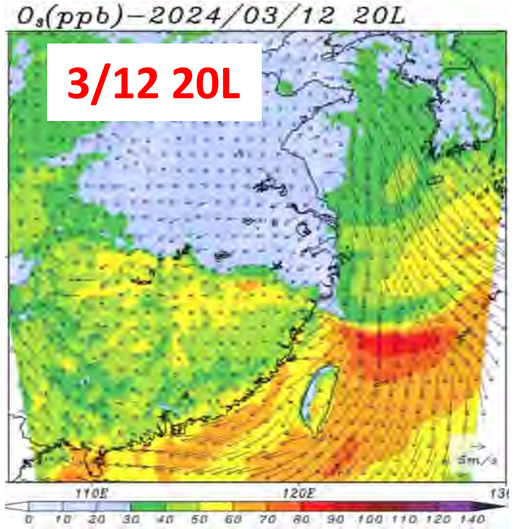
ASIA-AQ/KPEx IOP#3

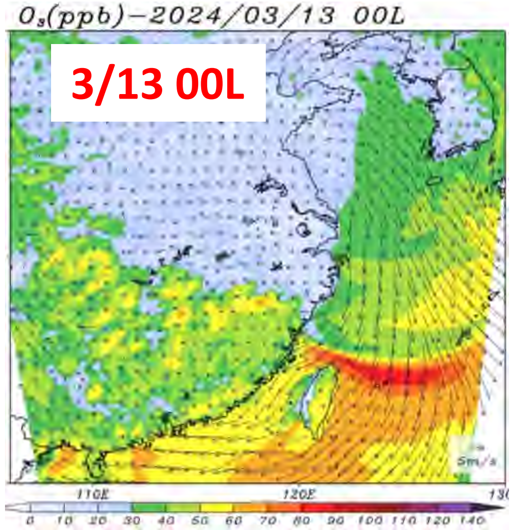
3/13 08L

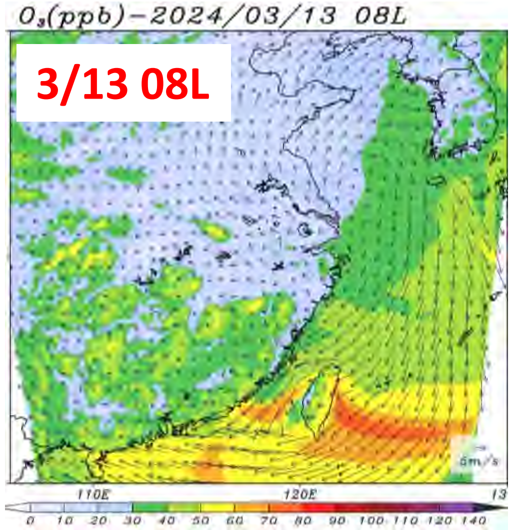


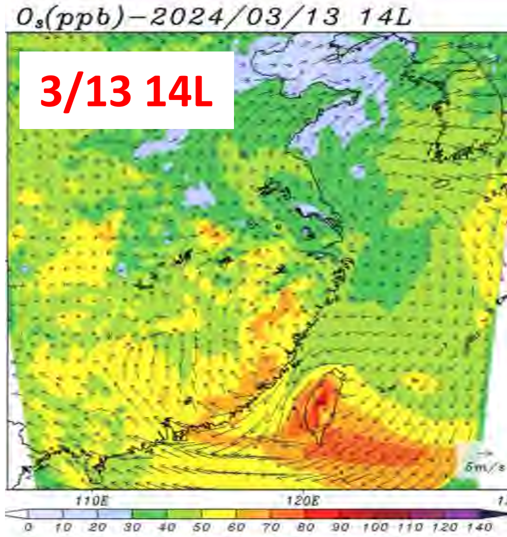
3/12 20L



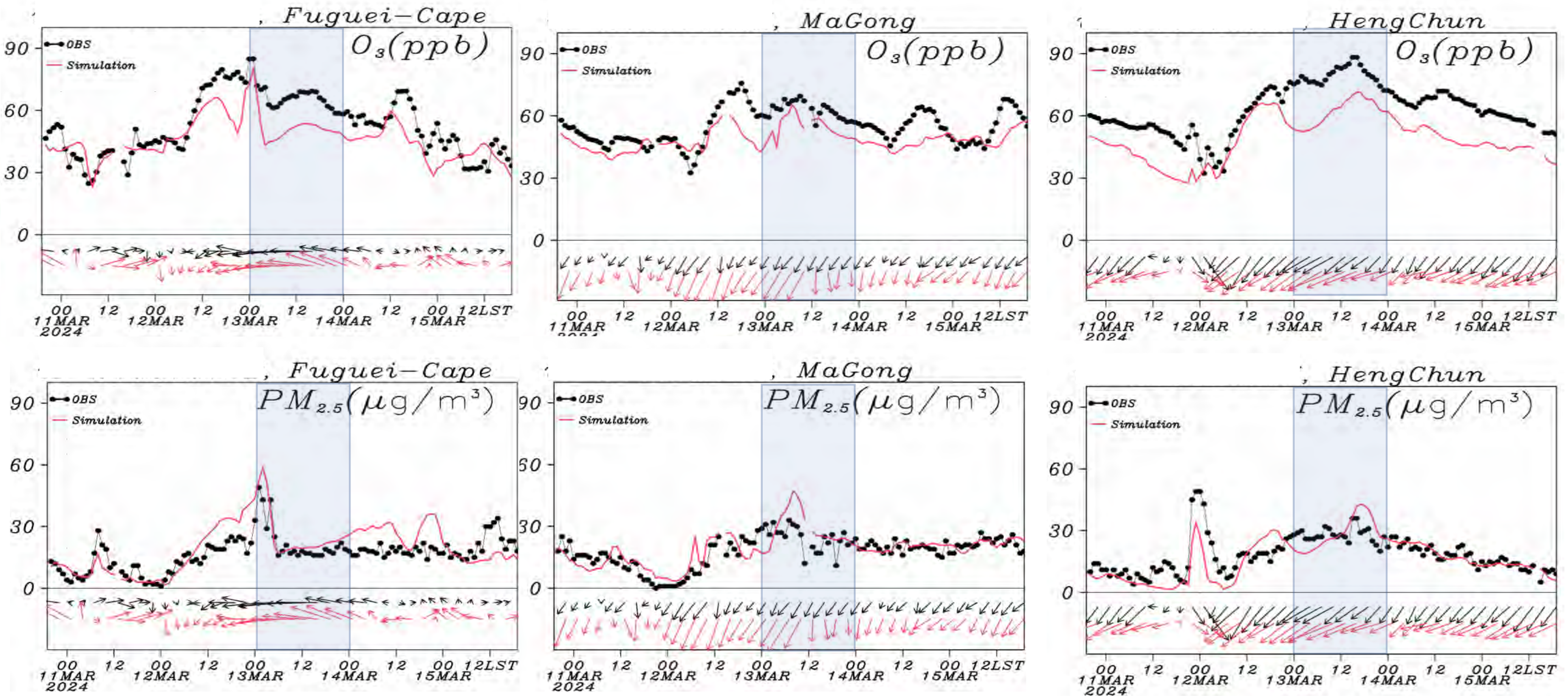




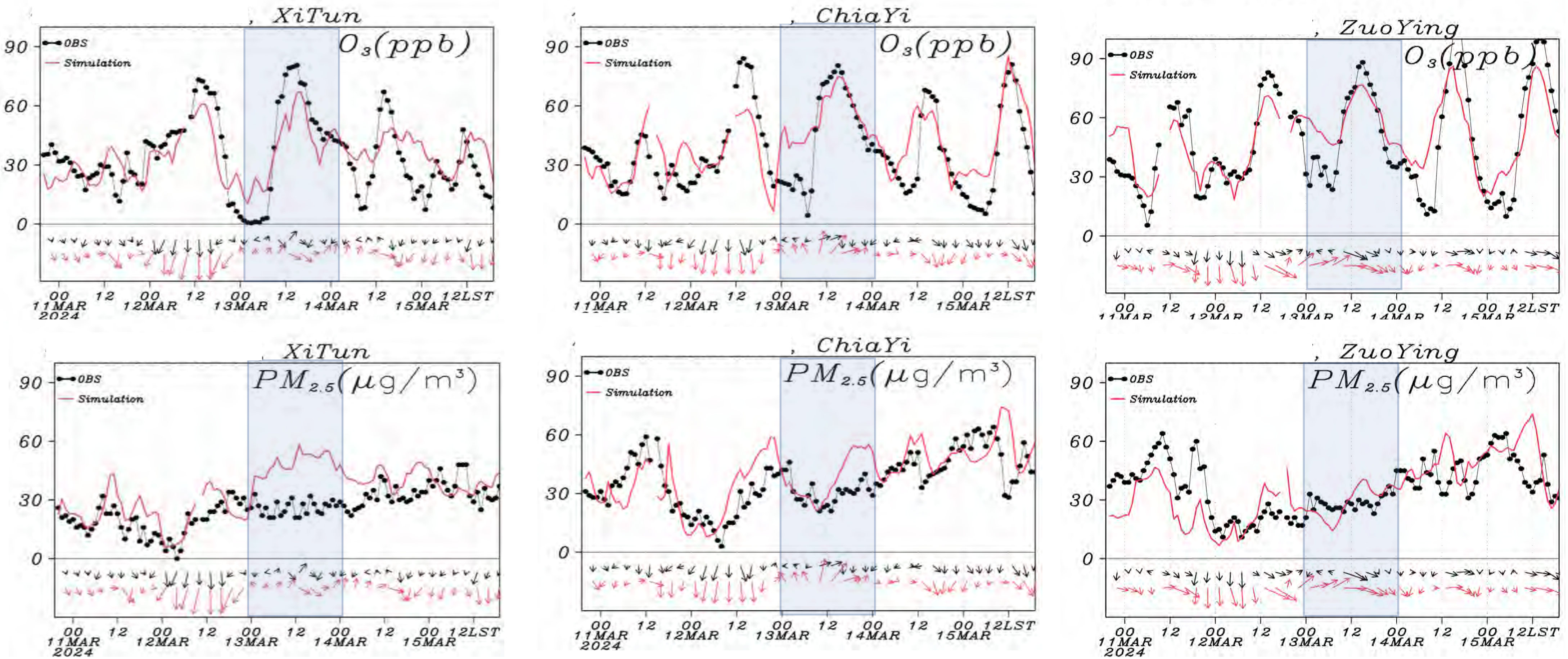




Model Validation at Background Stations

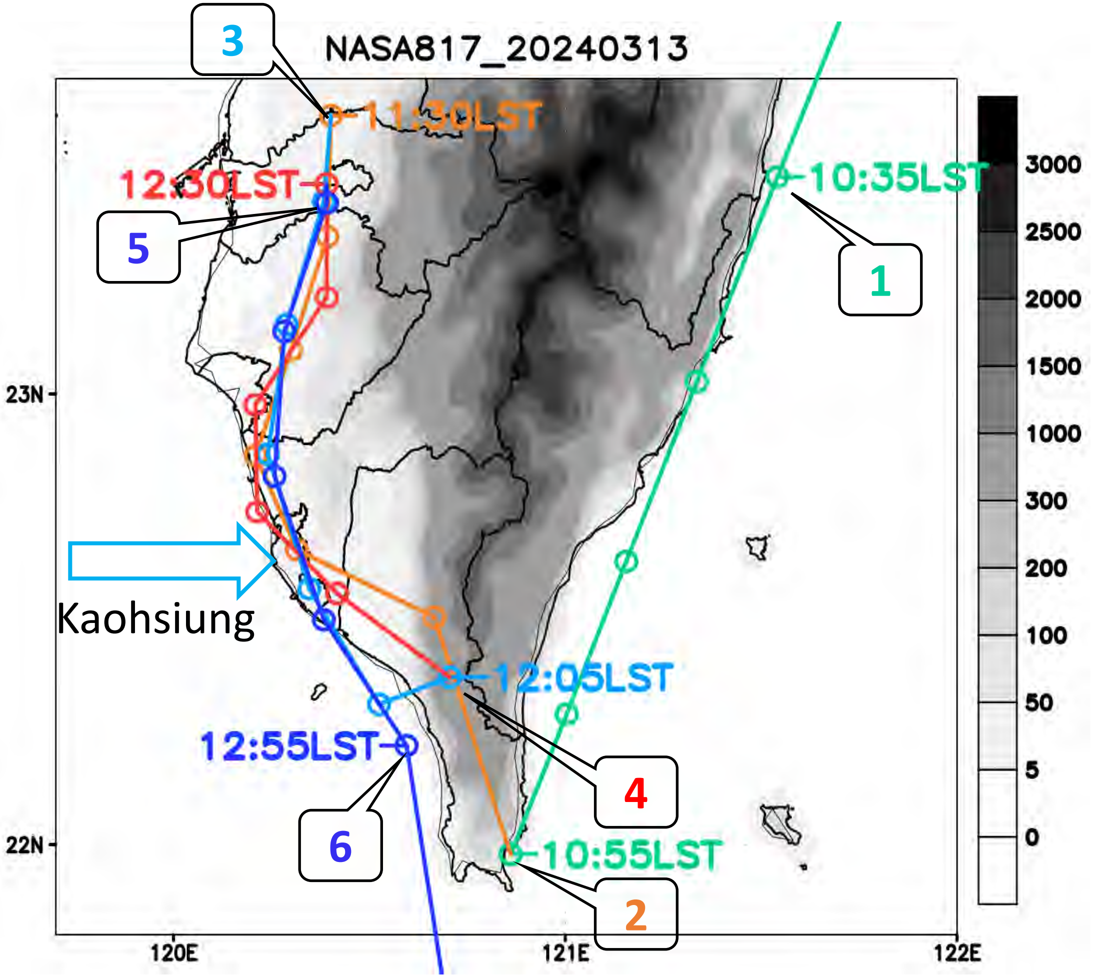


Model Evaluation at City stations

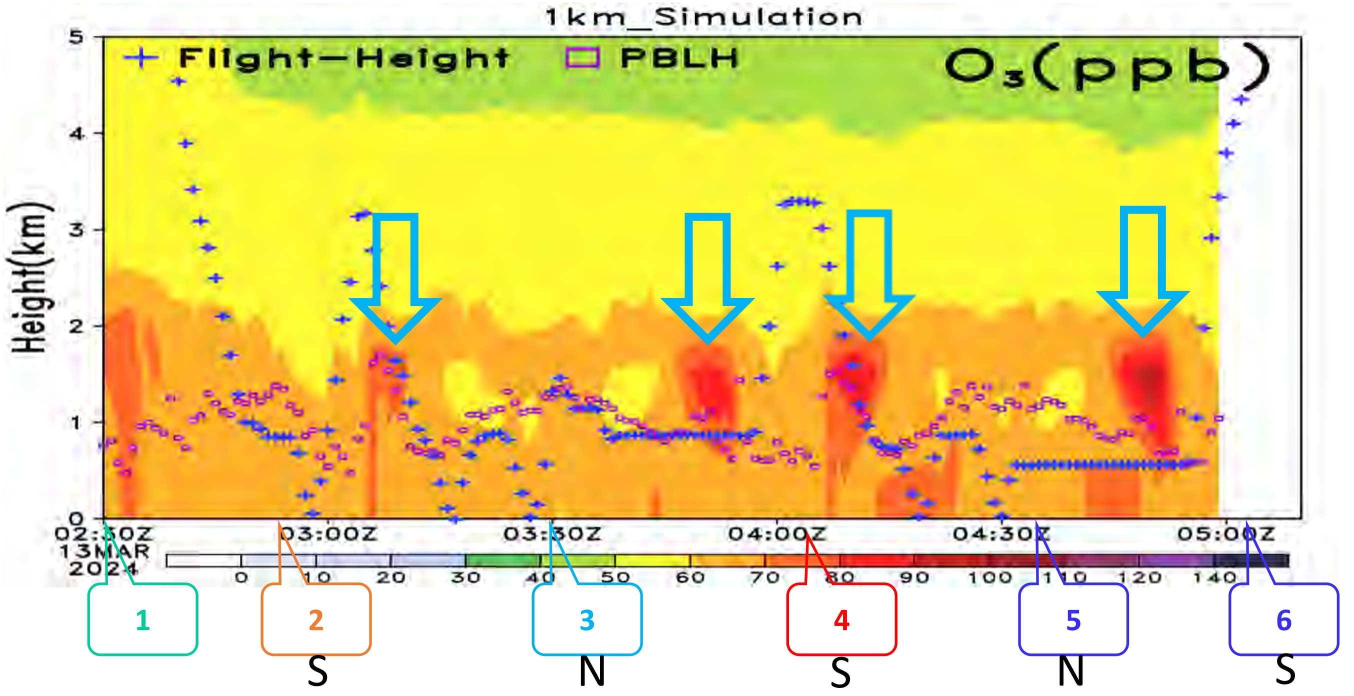


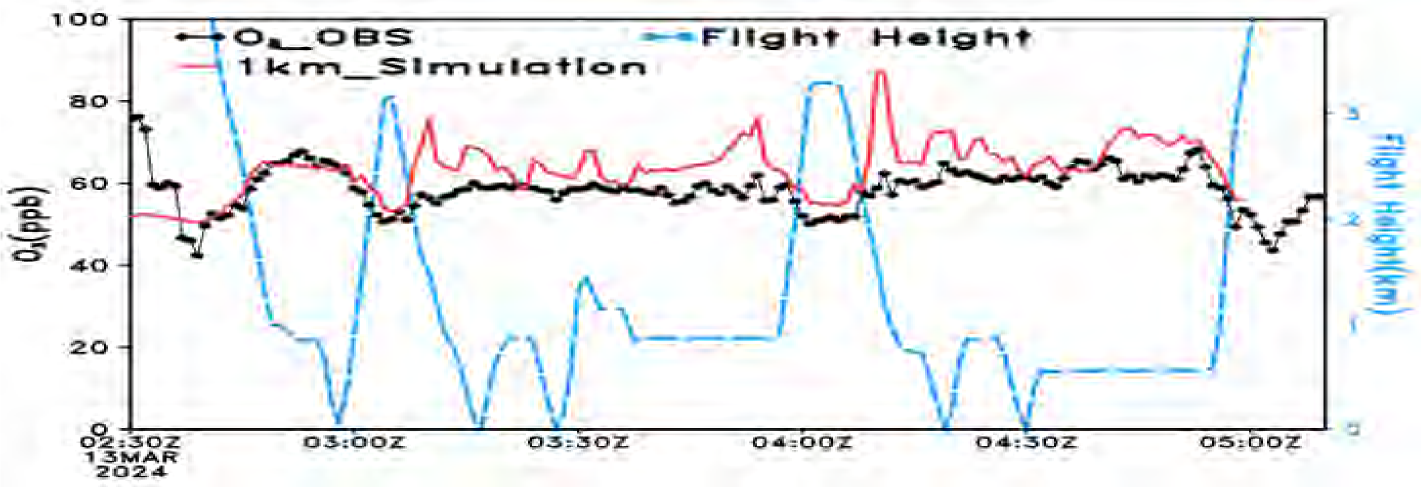
	T2m			WS10m			PM2.5			O_3			NO_2			SO_2		
	r	Bias	RMS	r	Bias	RMS	r	Bias	RMS	r	Bias	RMS	r	Bias	RMS	r	Bias	RMS
Kaohsiung	0.88	0.09	1.37	0.46	1.25	[illegible]	0.71	4.78	10.07	[illegible]	[illegible]	[illegible]	0.51	2.73	7.40	[illegible]	1.01	[illegible]
Western Taiwan	0.92	0.71	1.20	0.93	1.54	2.01	0.83	1.24	4.85	[illegible]	[illegible]	[illegible]	0.58	-2.34	[illegible]	[illegible]	1.50	1.64

Aircraft measurement (NASA-DC8) and Modeling (13 March)

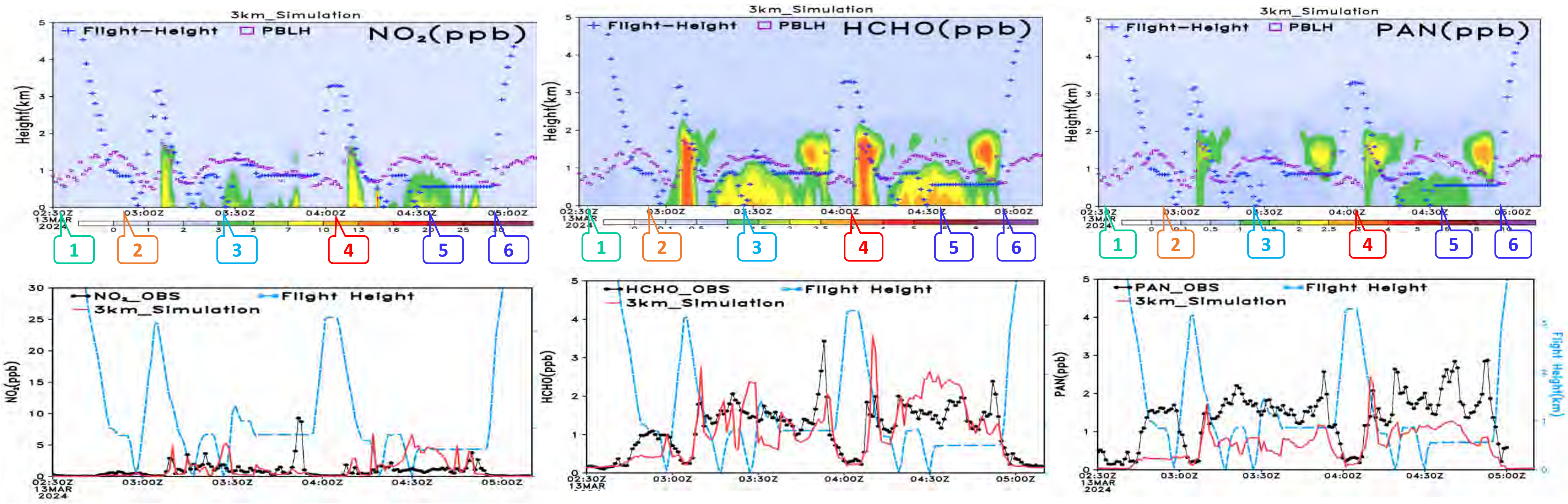


1→2 →3 →4 →5→6



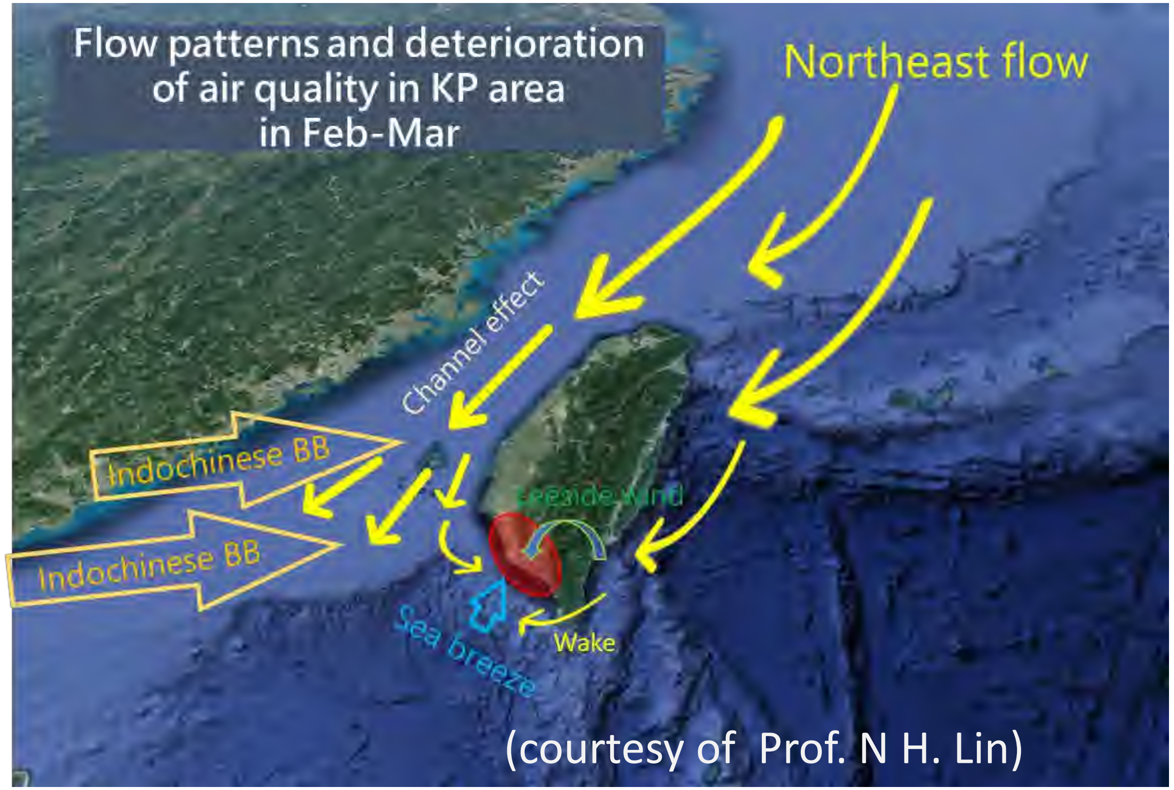


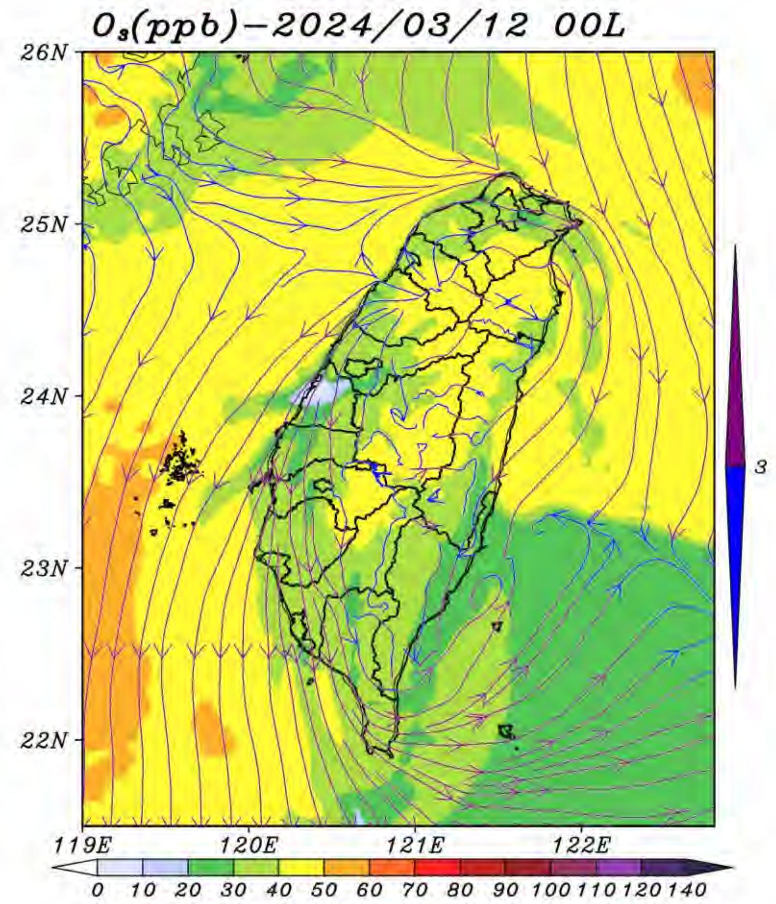
Aircraft measurement (NASA-DC8) and Modeling (13 March)



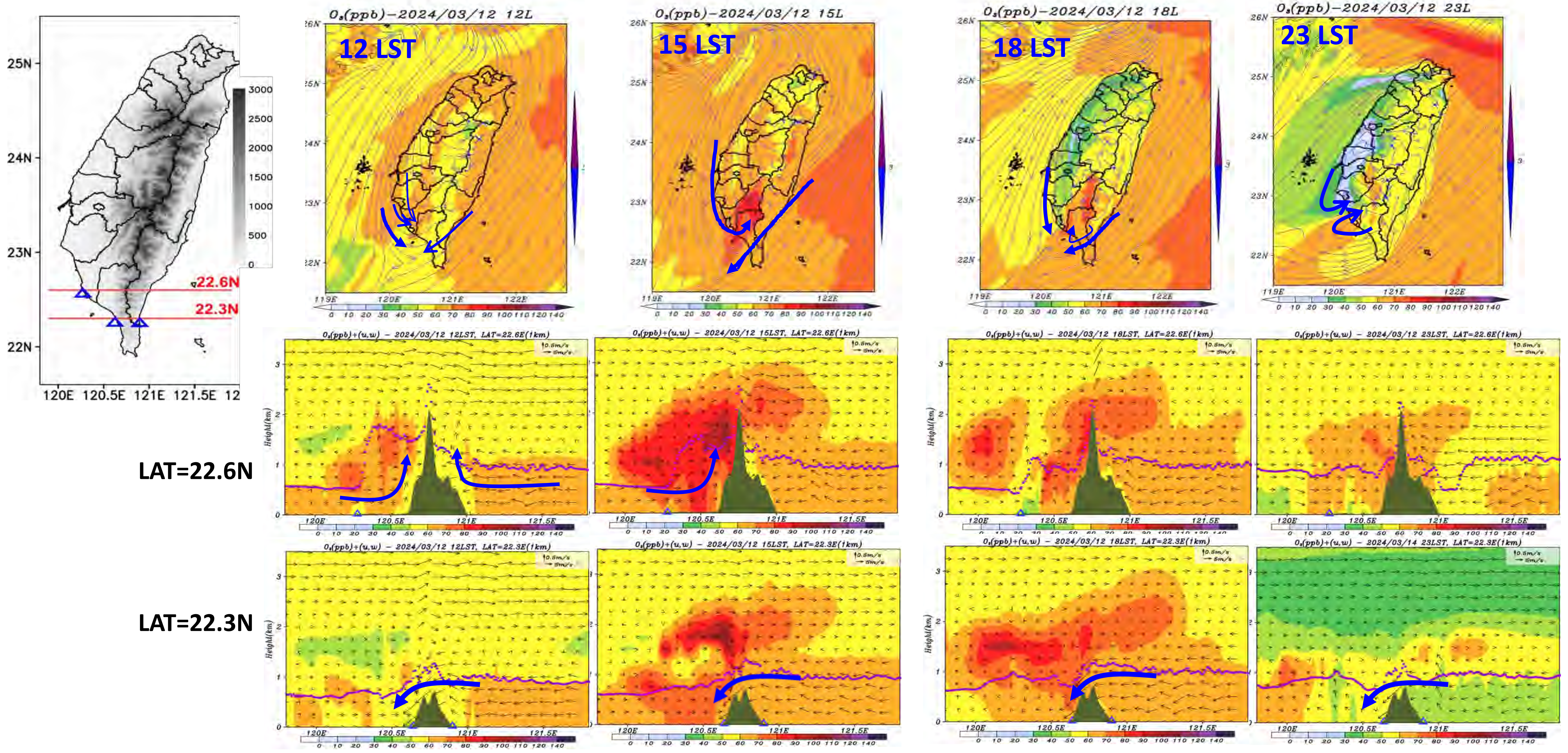
	O3	NO2	HCHO	PAN
		3km resolution		
r	0.46	0.19	0.73	0.62
Bias	4.19	0.19	-0.07	-0.71
RMS	7.66	1.78	0.54	0.89
		1km resolution		
r	0.41	0.28	0.73	0.69
Bias	4.43	0.10	-0.10	-0.72
RMS	7.80	1.70	0.53	0.87

Q: When and how do the formation of lee vortices and the lee wake effect impact the air quality of the Kaohsiung-Pingtung (KP) area?

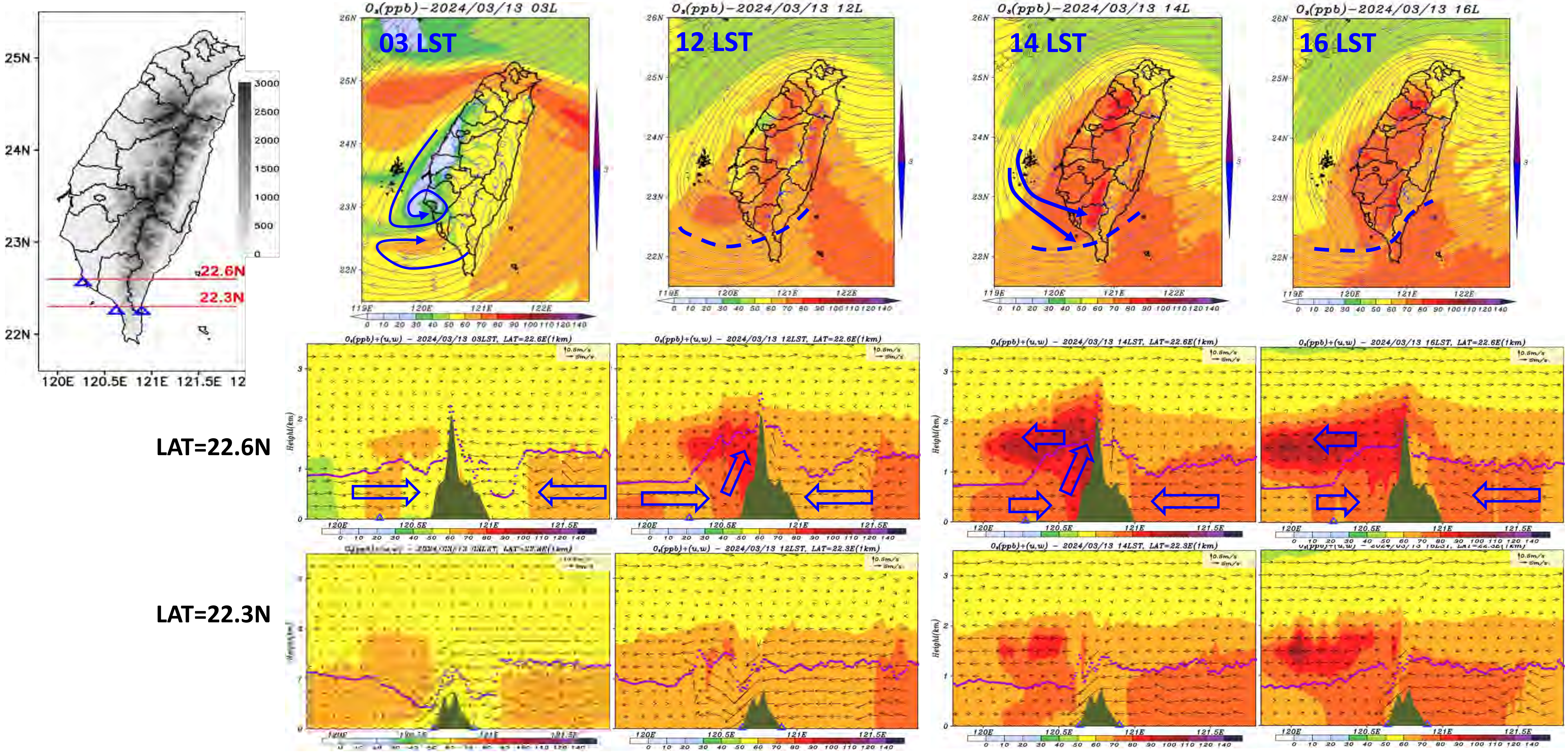




Ozone Simulation on 12 March,2024

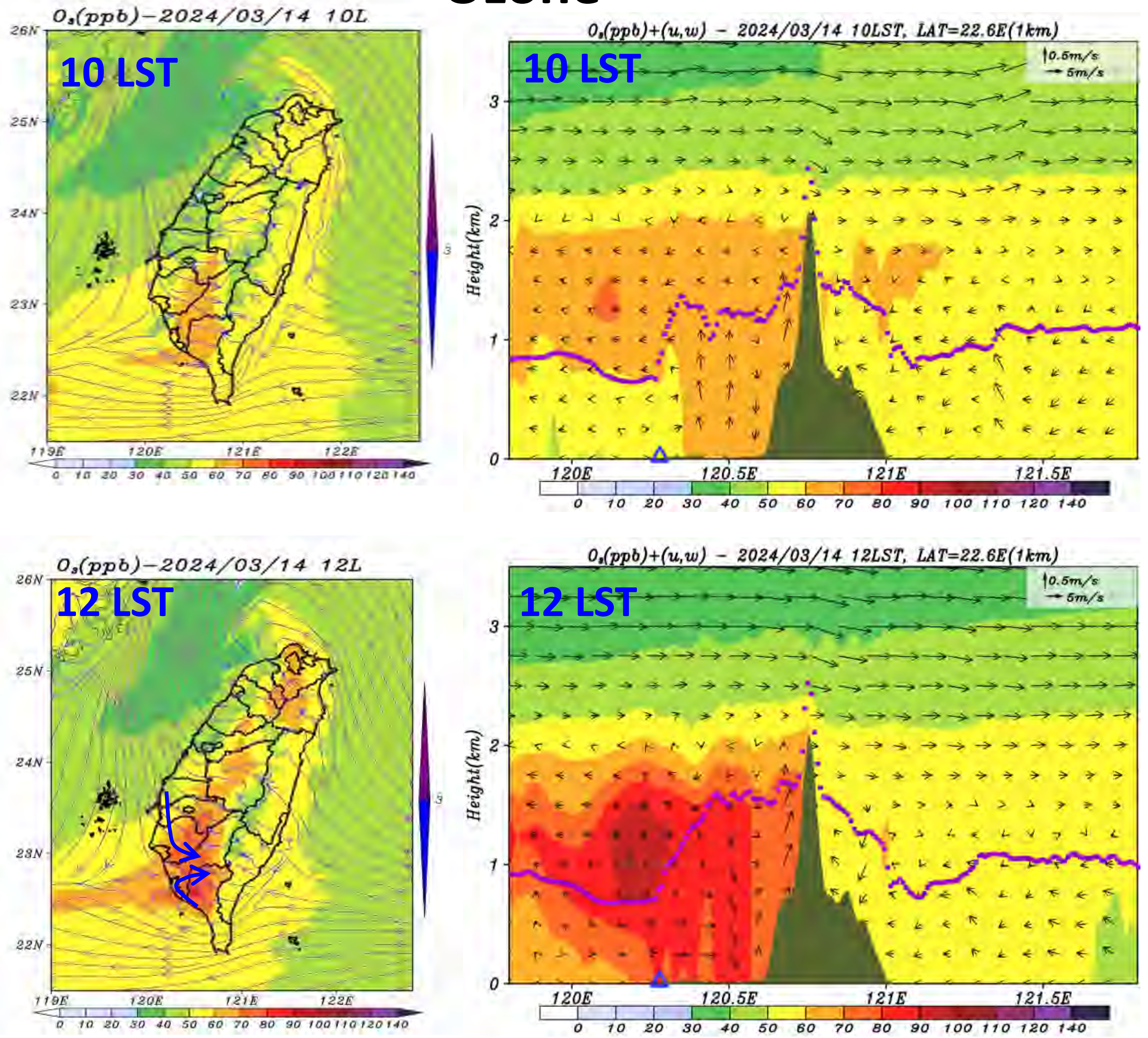


Ozone Simulation on 13 March,2024

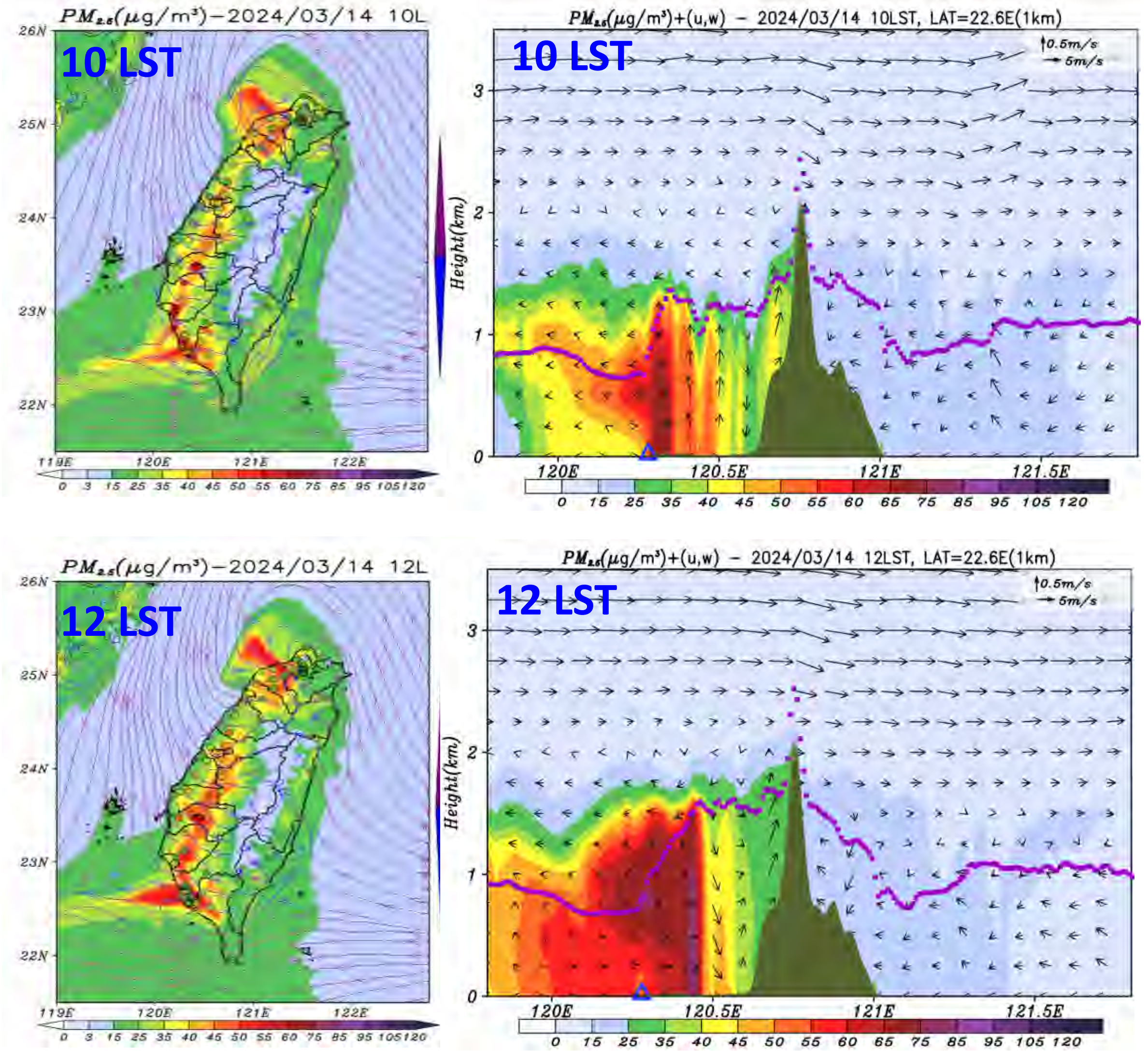


Ozone and PM2.5 Simulation on 14 March 2024

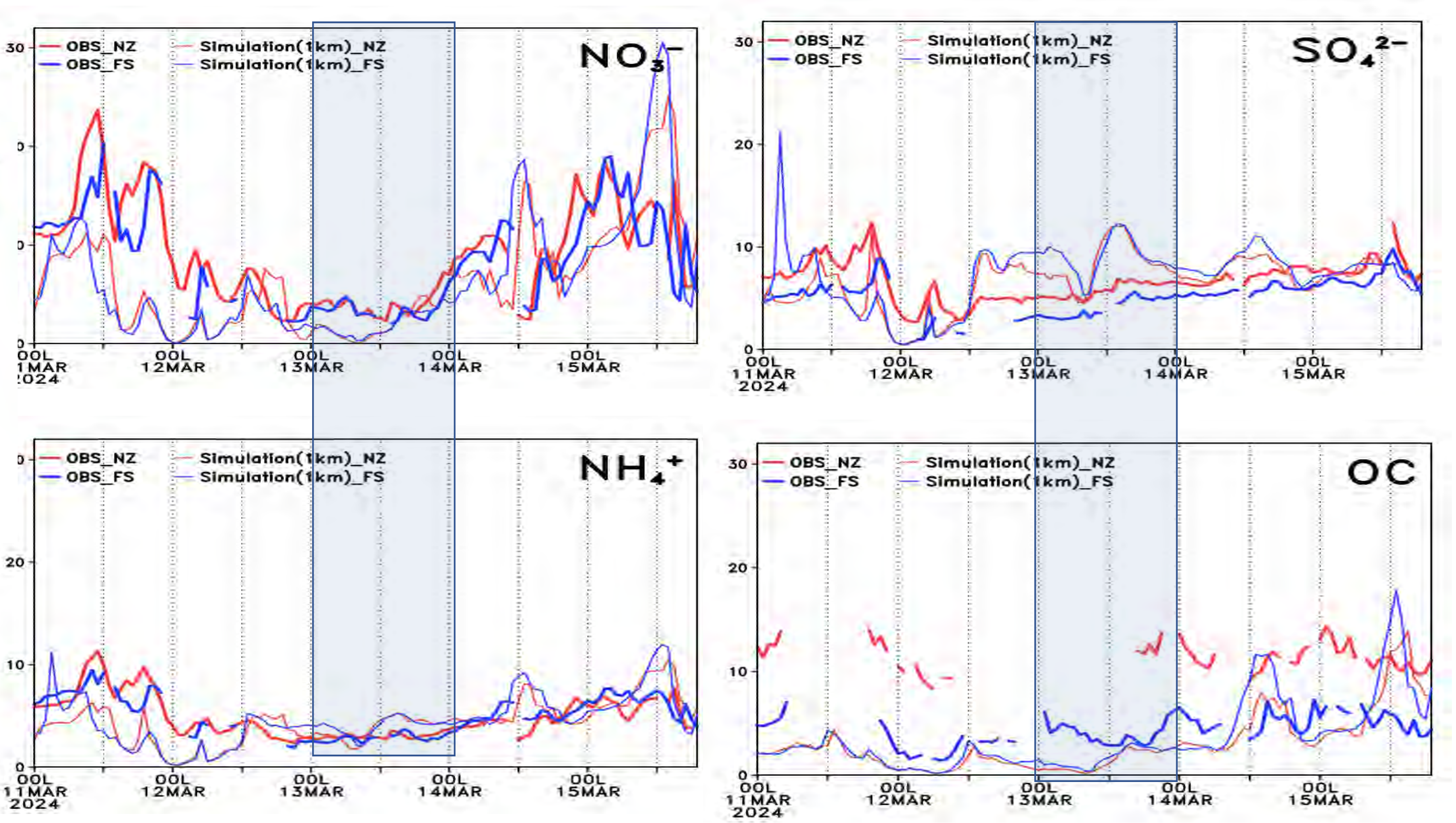
Ozone



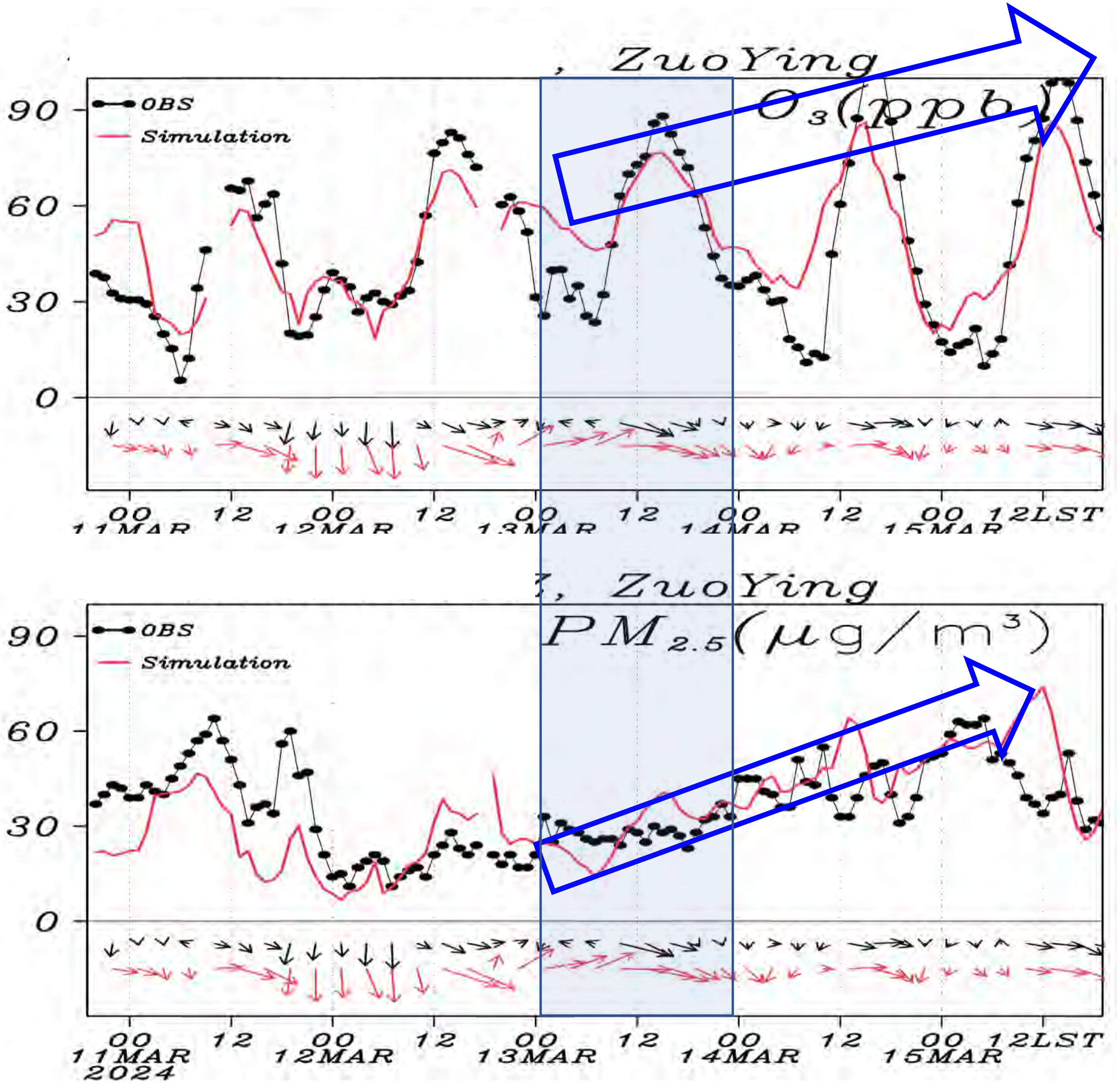
PM2.5



Ground Sampling and Modeling (11-15 March)



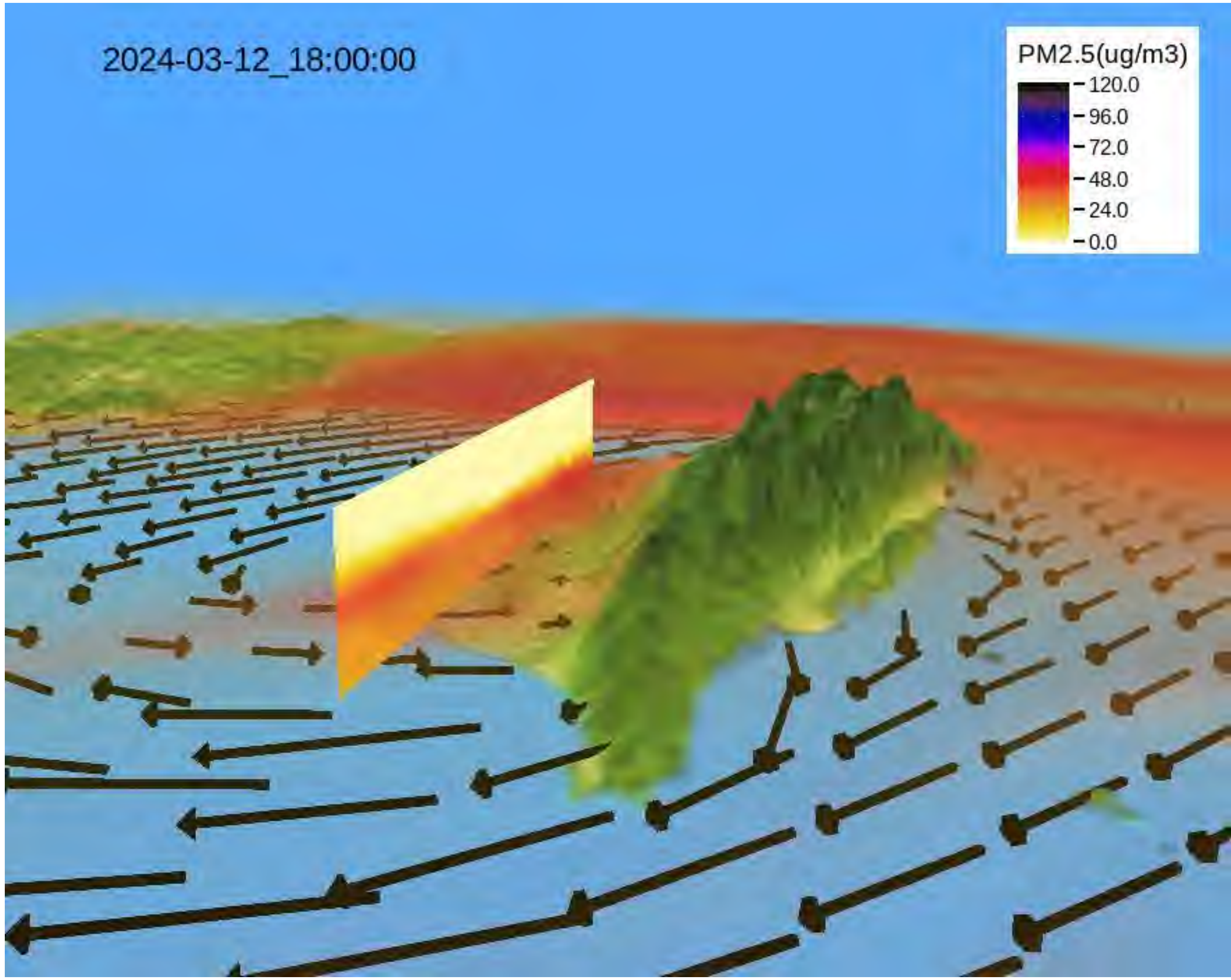
Sampling Data provided by Prof. T. C. Hsiao



- An increasing trend of PM2.5 and daytime peak ozone was observed in the Kaohsiung area after IOP#3.

Summary

- The variation of continental outflows and their interactions with Taiwan's Central Mountain Range (CMR) are crucial in the air pollution episode during IOP#3.
- The formation of lee vortices allows air pollutants to accumulate in Kaohsiung, creating a high-ozone environment that favors secondary aerosol formation.
- Additional observational data are needed to evaluate our model's performance and verify the proposed mechanism.



Thank you for your attention!!

環境變遷研究中心

空氣品質專題中心

Air Quality Research Center, RCEC

Characteristics of VOCs based on DC-8 and Ground-Level Measurements during 2024 ASIA-AQ IOPs in Taiwan

Chang-Feng Ou-Yang[1], Jhih-Yuan Yu[2], Jia-Lin Wang[3], James Crawford's TEAM[4], Neng-Huei Lin[1]

[1]Department of Atmospheric Sciences, National Central University, Taiwan
[2]Department of Monitoring and Information, Ministry of Environment, Taiwan
[3]Department of Chemistry, National Central University, Taiwan
[4]Langley Research Center, NASA, USA

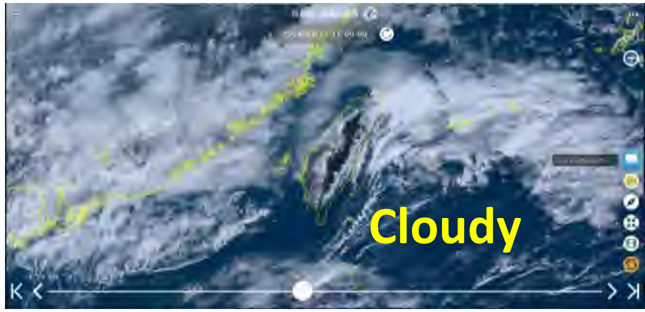
ASIA-AQ Taiwan Science Flights

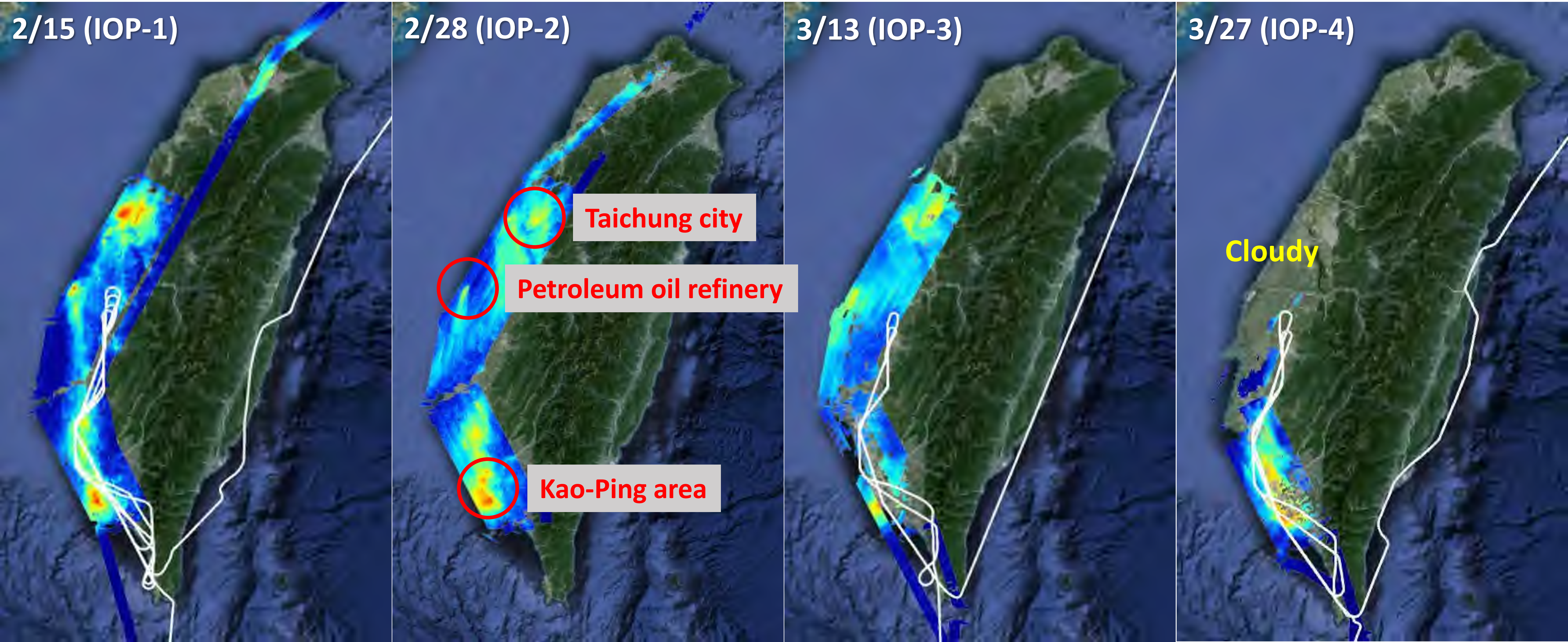
3 Days with G-III and DC-8: 2/15, 3/13, 3/27

1 Day with G-III alone: 2/28

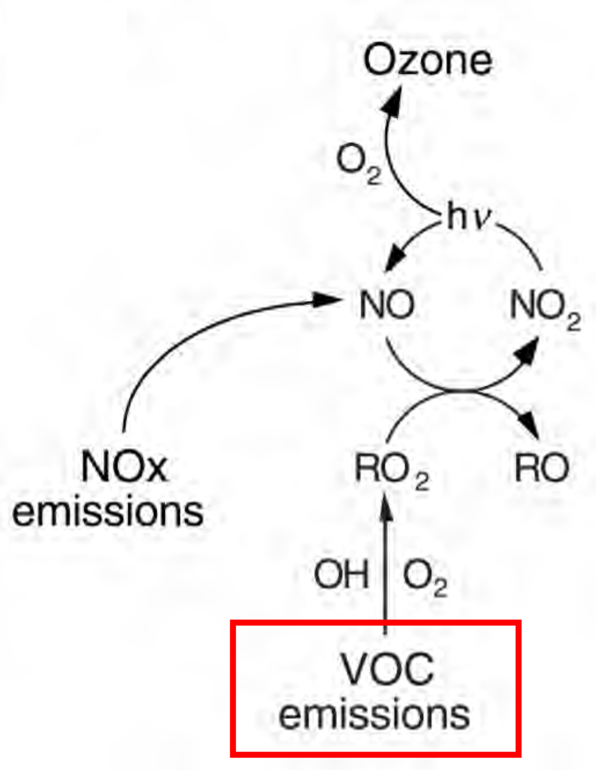
G-III NO_2

GCAS Preliminary
Slant column data





VOC measurements on DC-8



Whole Air Sampling (WAS)

PTR-MS

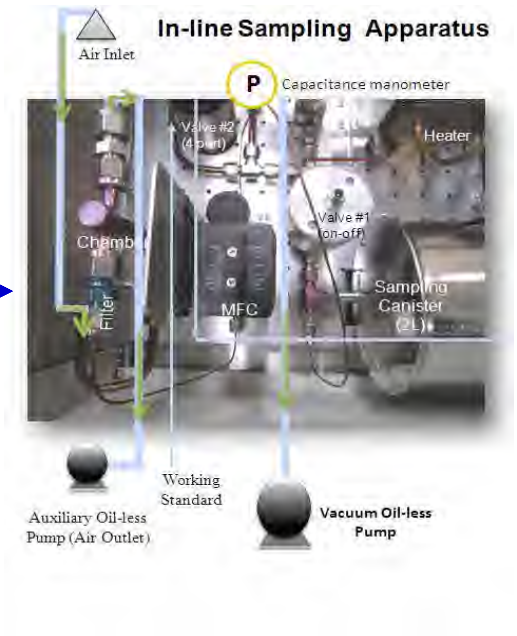
GC-MS at UCI

Data credit: WAS (Donald Blake), PTR-MS (Armin Wisthaler)

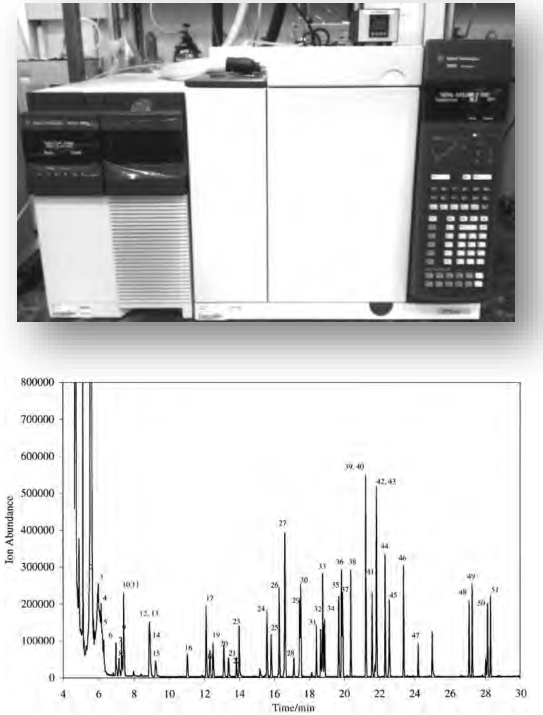
UAV sampling and analysis

Chang et al., 2016 & 2018.

Drone with a canister



Cryo-enrichment stage

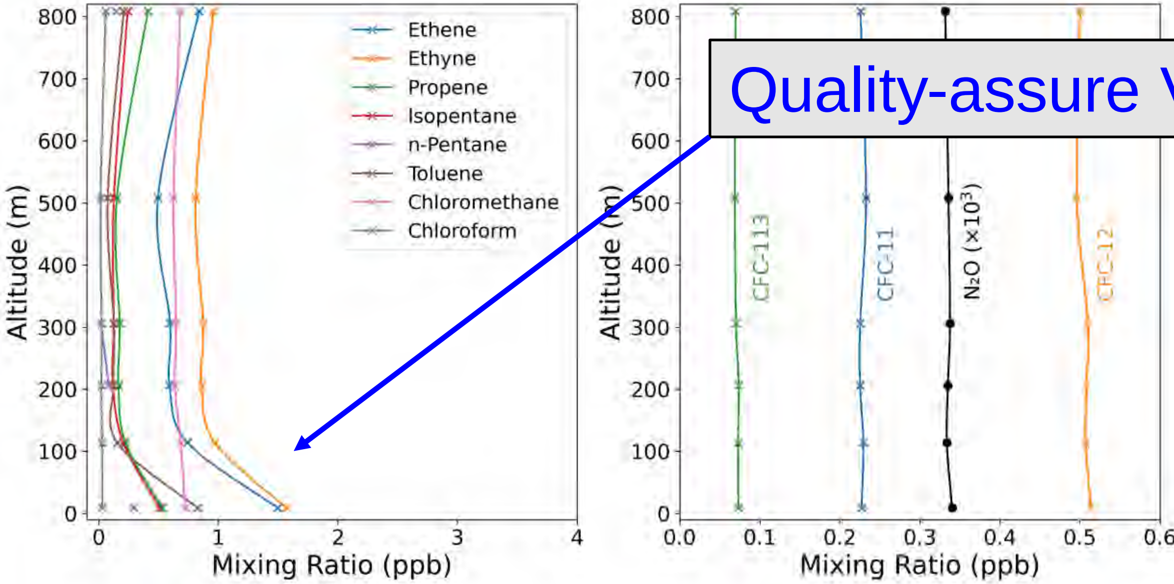


GC/MS/FID

Sampling height	IOP 1	IOP 2	IOP 3	IOP 4	Total
0m, 100m, 200m, 300m, 500m, 800m	Time: 2/14-2/16 Samples: n=18	Time: 2/28-2/29 Samples: n=12	Time: 3/12-3/14 Samples: n=20	Time: 3/27-3/29 Samples: n=18	N = 68 samples

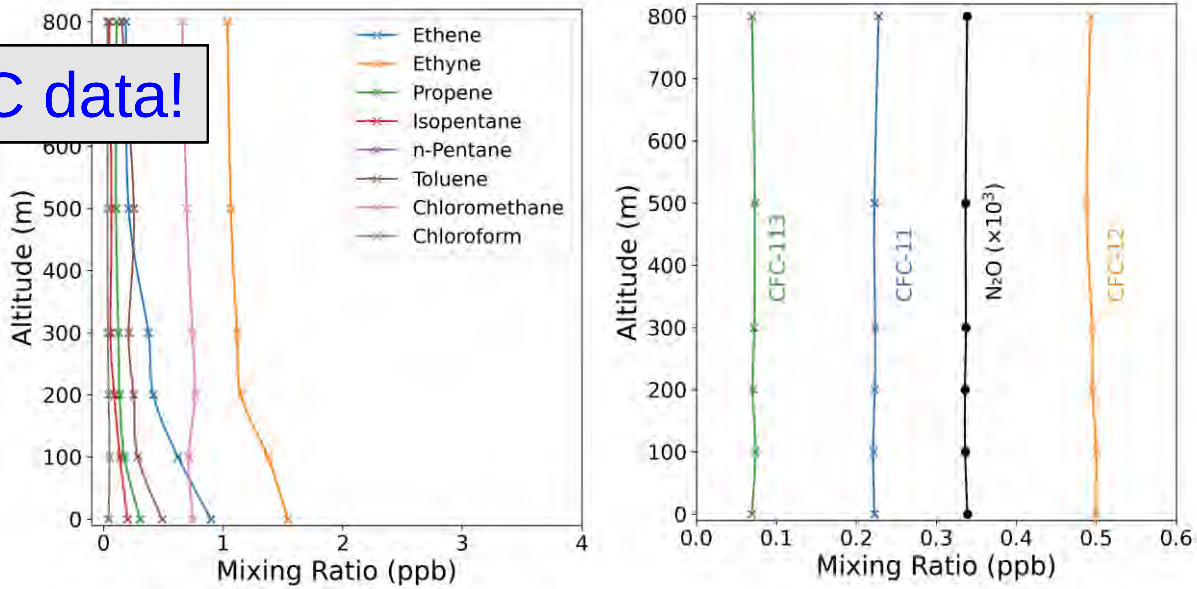
Variable vs. homogeneous – a sharp contrast

IOP1: 2024-02-15 02:30:00

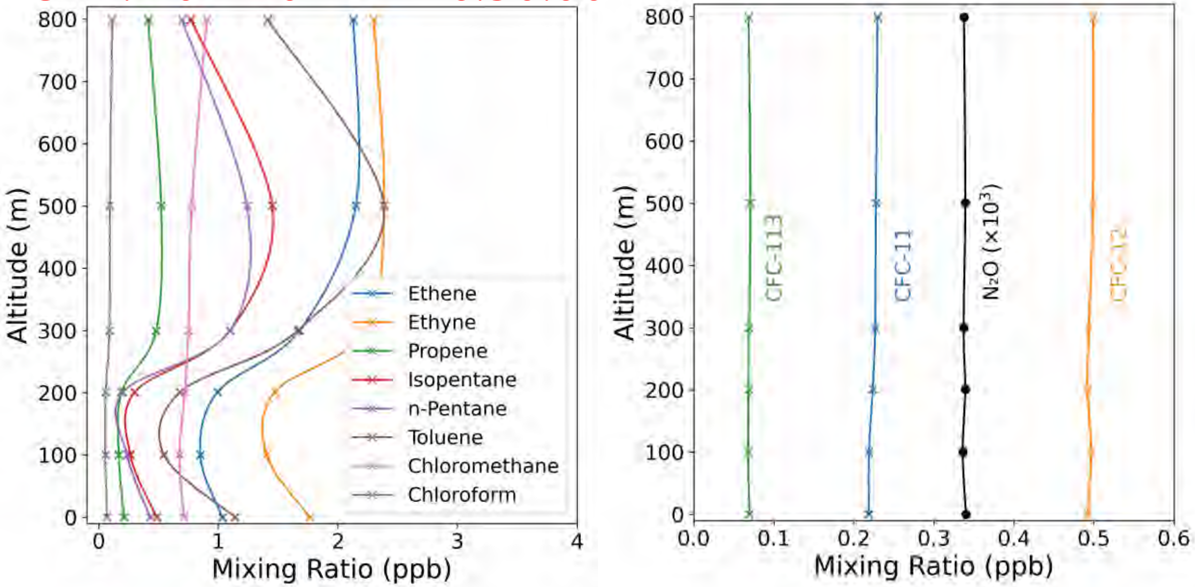


Quality-assure VOC data!

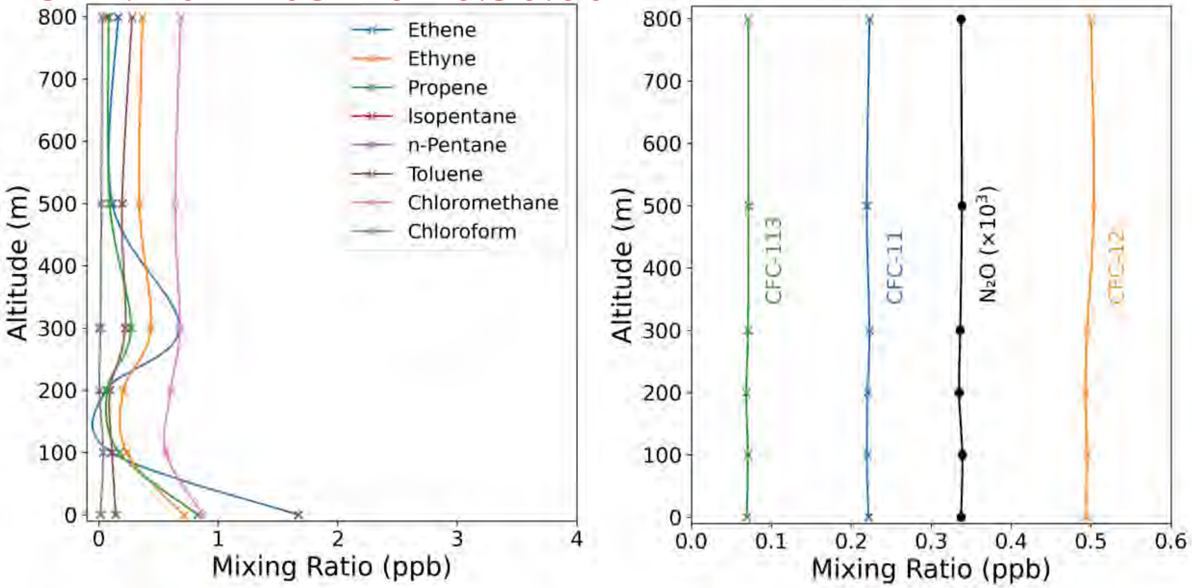
IOP3: 2024-03-12 20:30:00



IOP2: 2024-02-27 16:30:00

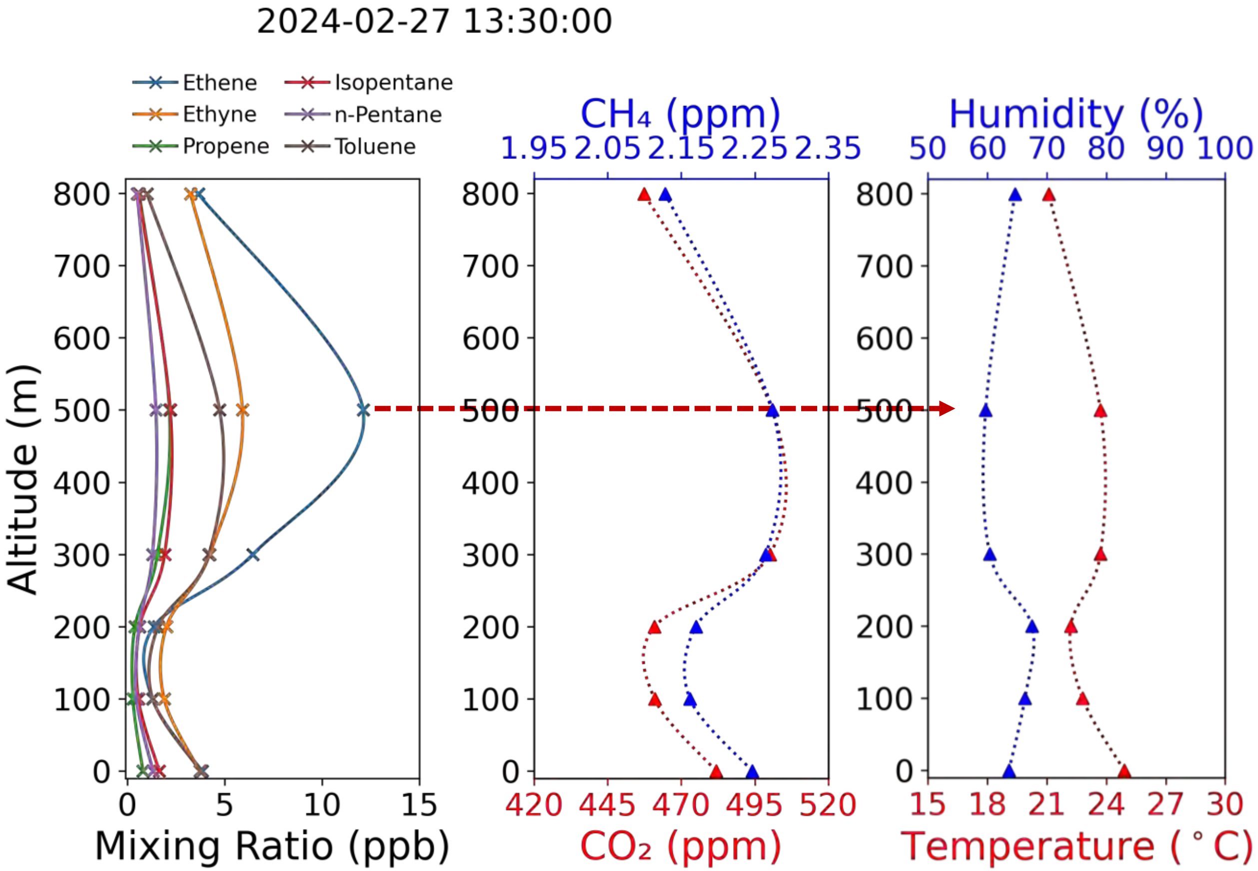


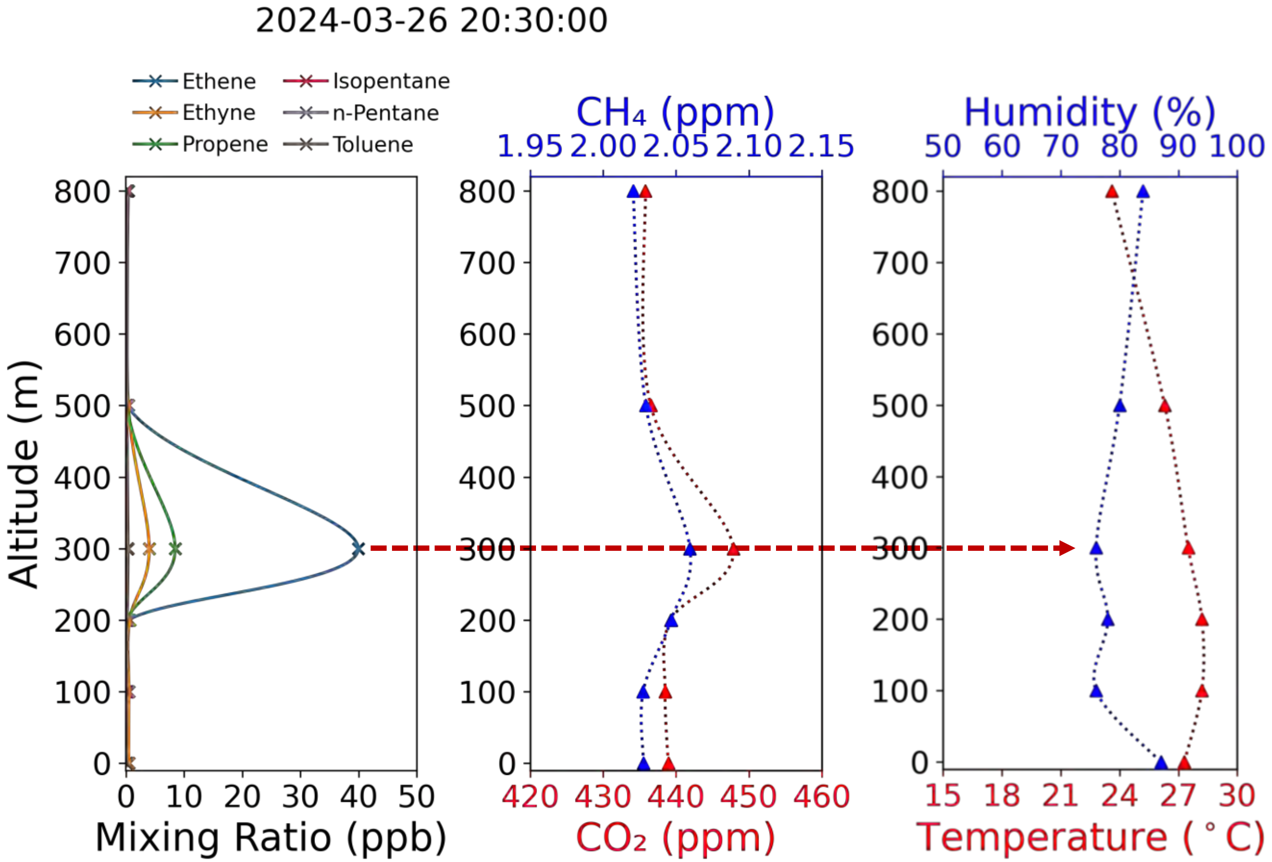
IOP4: 2024-03-26 16:30:00



Plumes from flares?

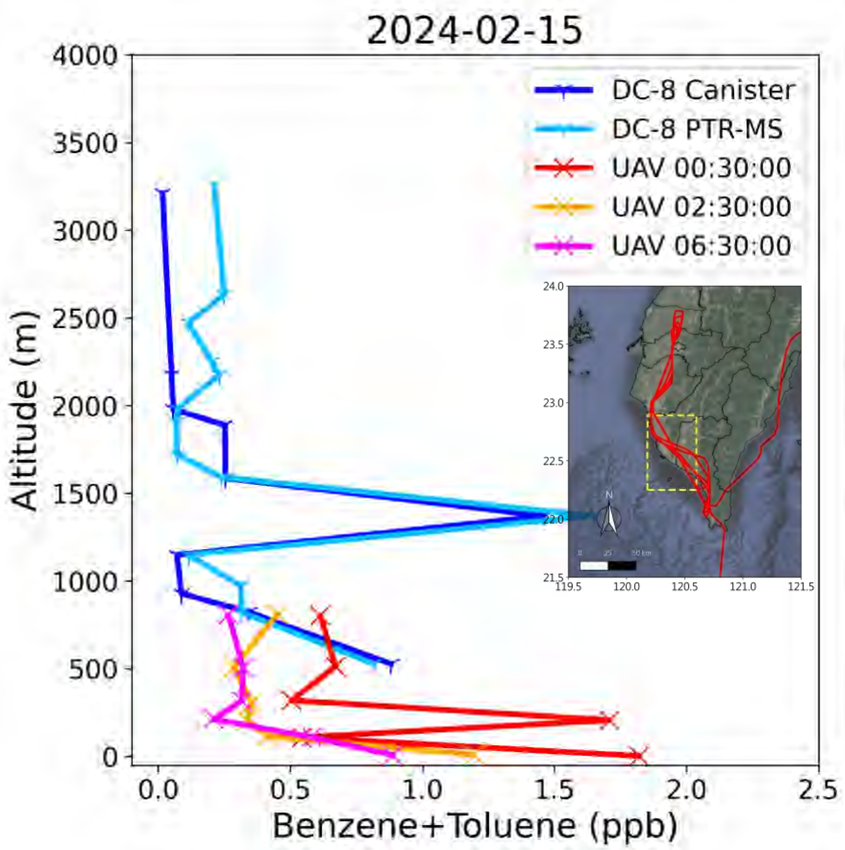
Ethene's bulge correlates with higher CO_2, CH_4, T(°C), and lower R.H., possibly a burning source



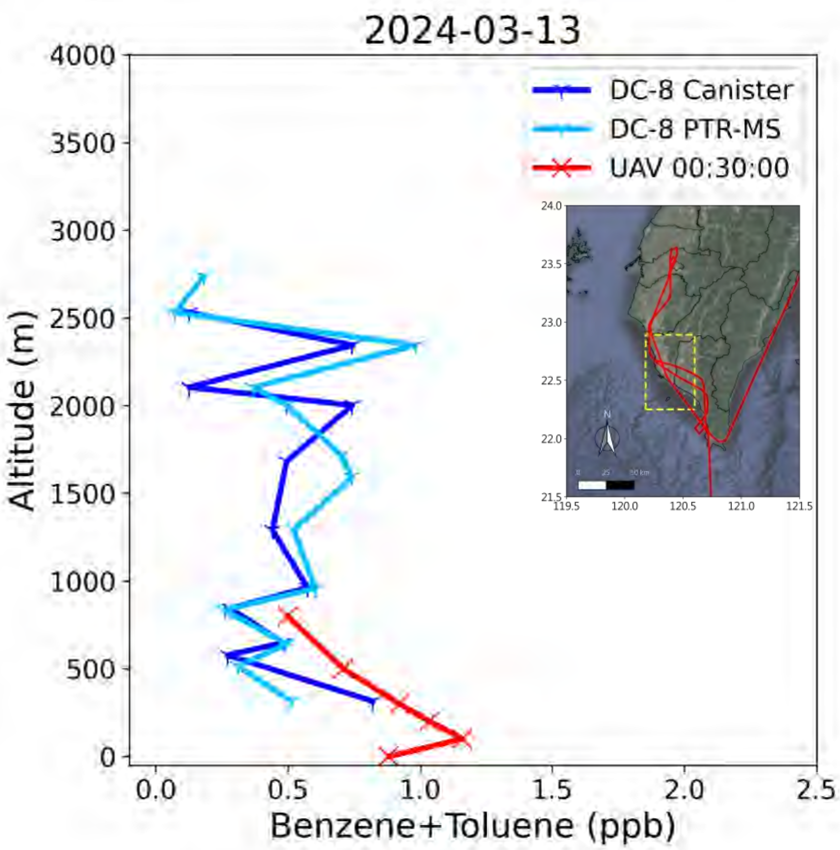


Using both DC-8 and UAV to constrain the mixing ratio range for Benzene + Toluene

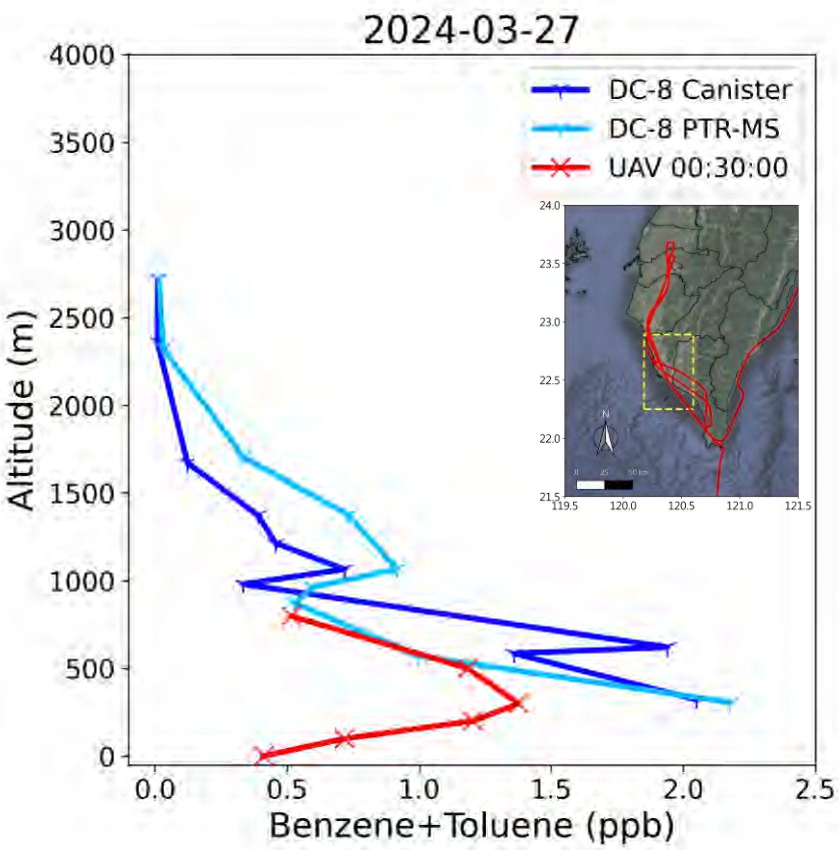
IOP 1



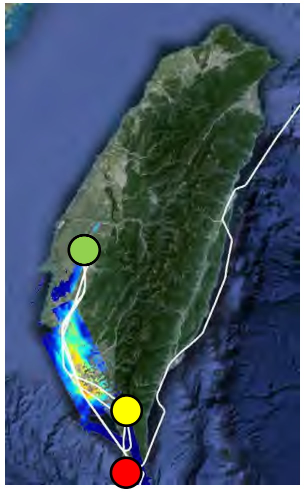
IOP 3



IOP 4



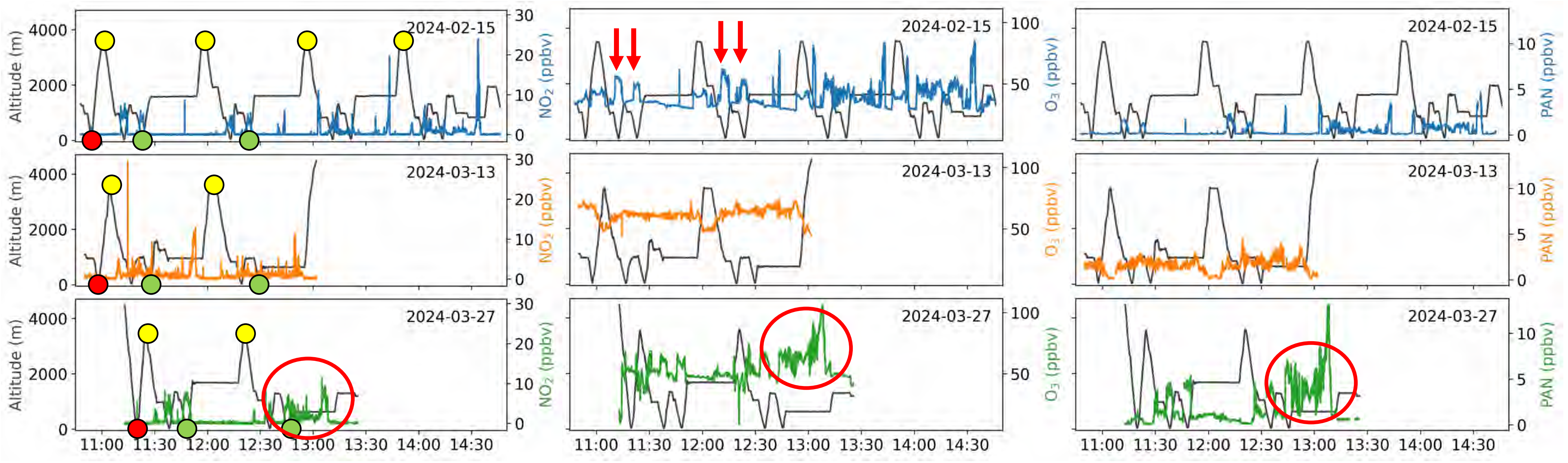
Data credit: WAS (Donald Blake), PTR-MS (Armin Wisthaler)



Time-series DC-8 data in Taiwan

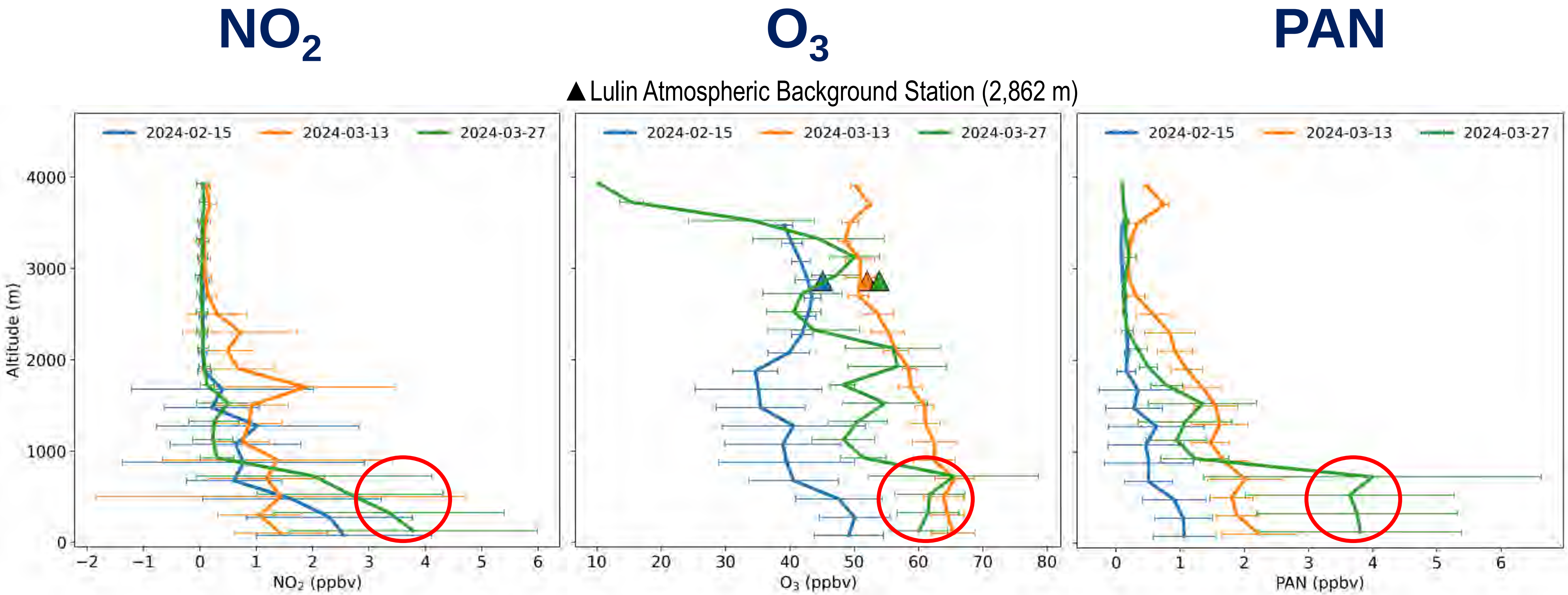
- Concentrations of the air pollutants generally increased with decreasing elevation.
- Little variation of O_3 was observed on 13 Mar (IOP-3), implying a well-mixed condition.
- Significant increased O_3 and PAN on 27 Mar (IOP-4) suggest a strong photochemical process.

NO_2 | O_3 | PAN



Data credit: O_3 (Jason M. St. Clair), NO_2 (Jason M. St. Clair), PAN (L. Gregory Huey)

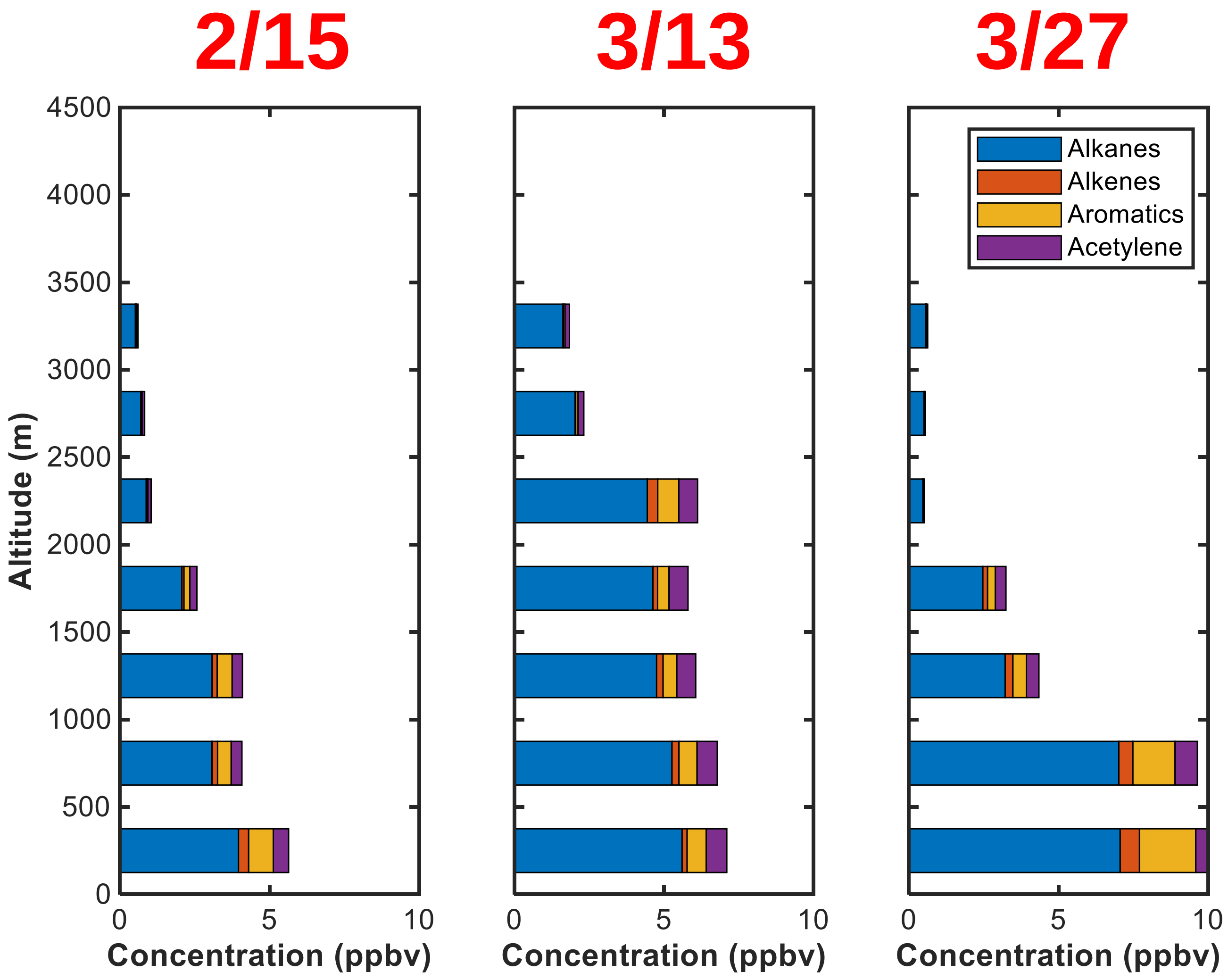
Average vertical profiles



- Good agreement in O_3 with Lulin Atmospheric Background Station (2,862 m ASL).
- Low variability but increased level of vertical O_3 profile on 13 Mar (IOP-3) implies a homogeneous condition.
- Again, significant increased O_3 and PAN below 800 m on 27 Mar (IOP-4) suggest a strong photochemical process.

Data credit: O_3 (Jason M. St. Clair), NO_2 (Jason M. St. Clair), PAN (L. Gregory Huey)

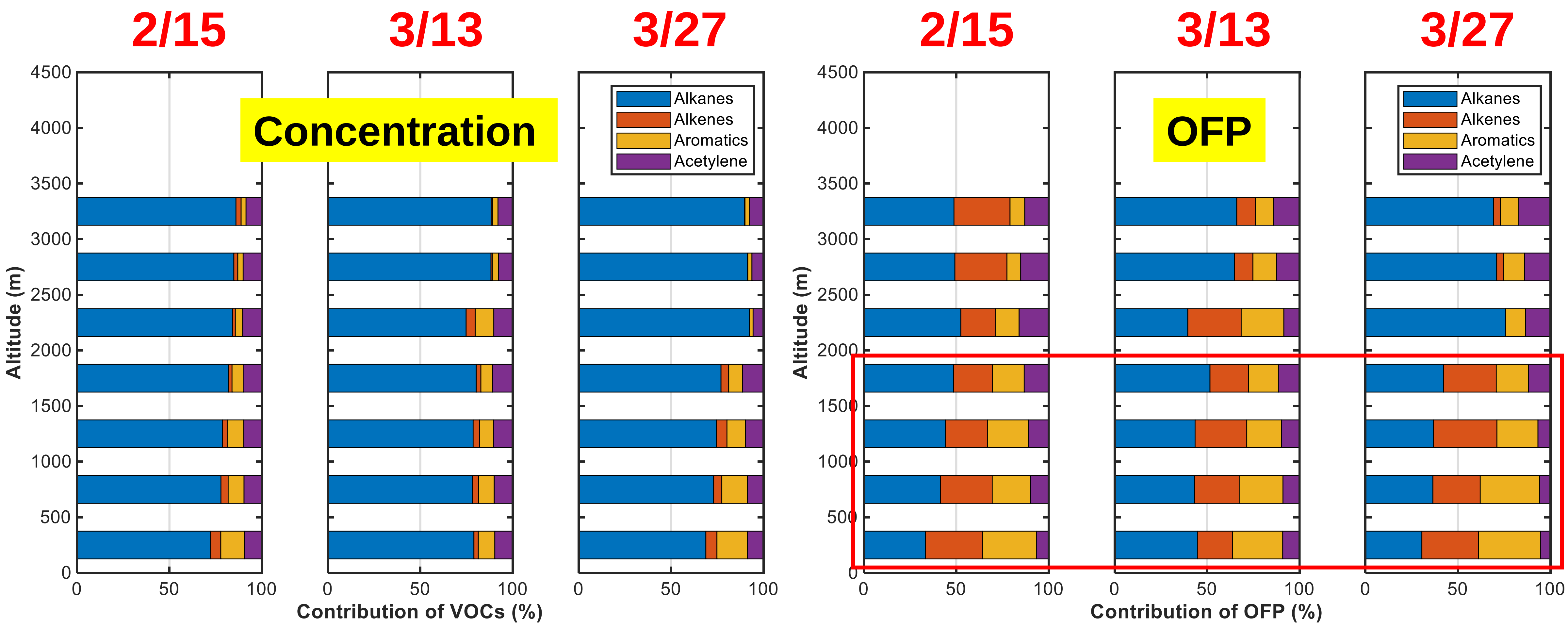
DC-8
VOC vertical profiles



WAS analyzed compounds:
C_2-C_{10} alkanes, alkenes, aromatics, and acetylene

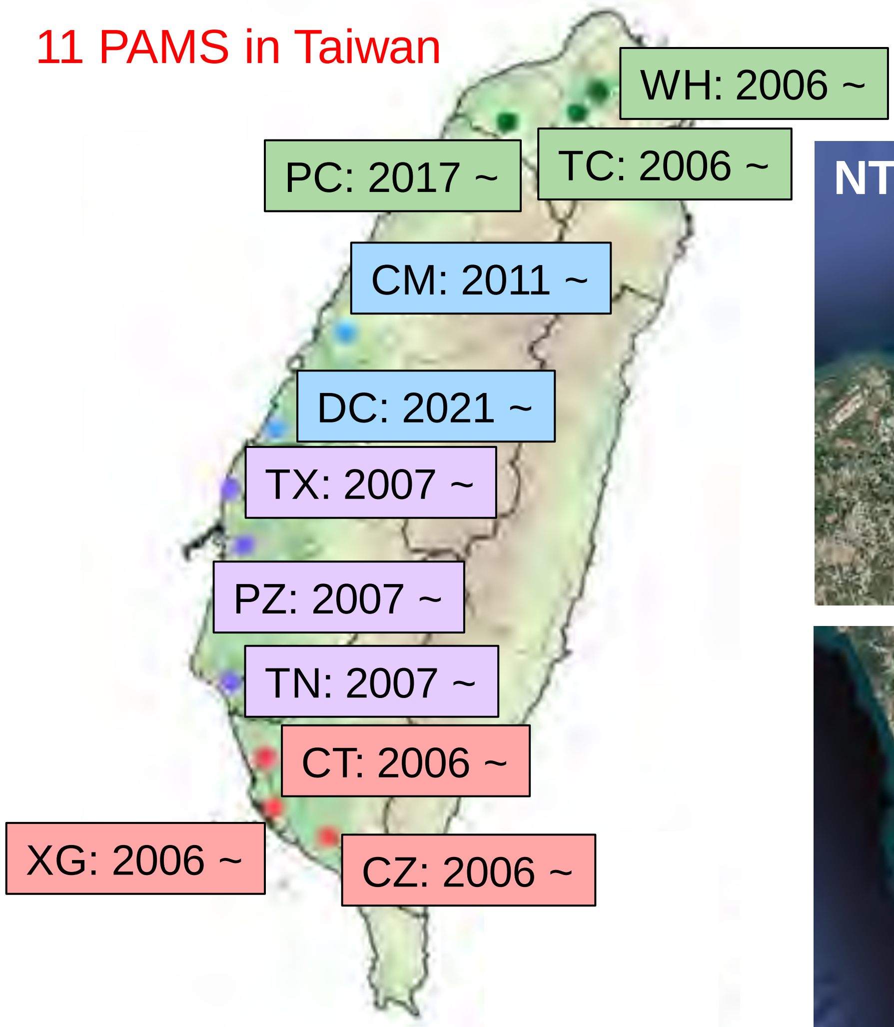
- VOC concentrations increased with decreasing elevation.
- Similar concentration and distribution of VOC groups were found below 2500 m, implying a well-mixed atmospheric condition on 13 Mar (IOP-3).
- Significant increased VOCs, especially aromatics, were observed below 1000 m on 27 Mar (IOP-4).

Ozone formation potential (OFP) of VOCs

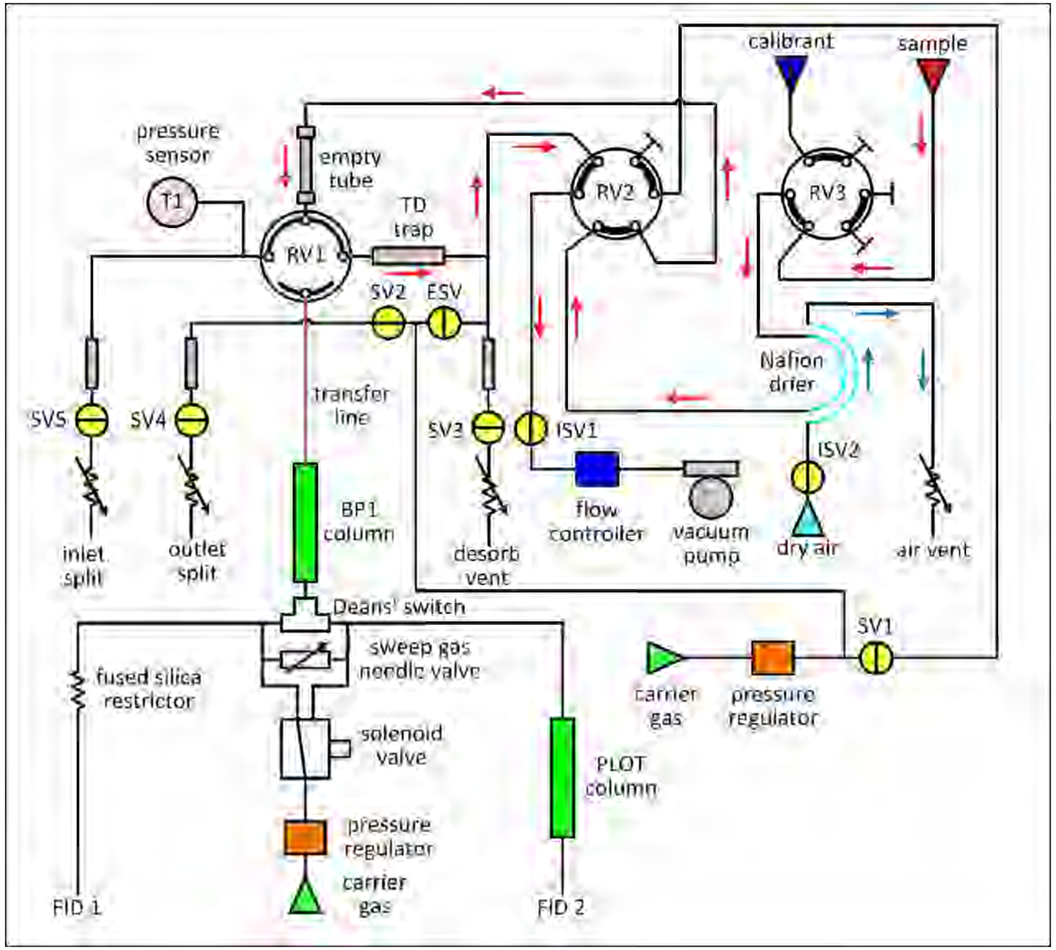


- Although the concentration distributions of alkenes and aromatics are low (10-25%), the distribution of their combined OFPs were 40-70%. The OFP distribution of aromatics was 34% within 500 m during IOP4 on 27 Mar.
- Ethane, ethylene, and toluene are the compounds with greatest OFP in alkanes, alkenes, and aromatics, respectively.

Photochemical Assessment Monitoring Station (PAMS) Network in Taiwan

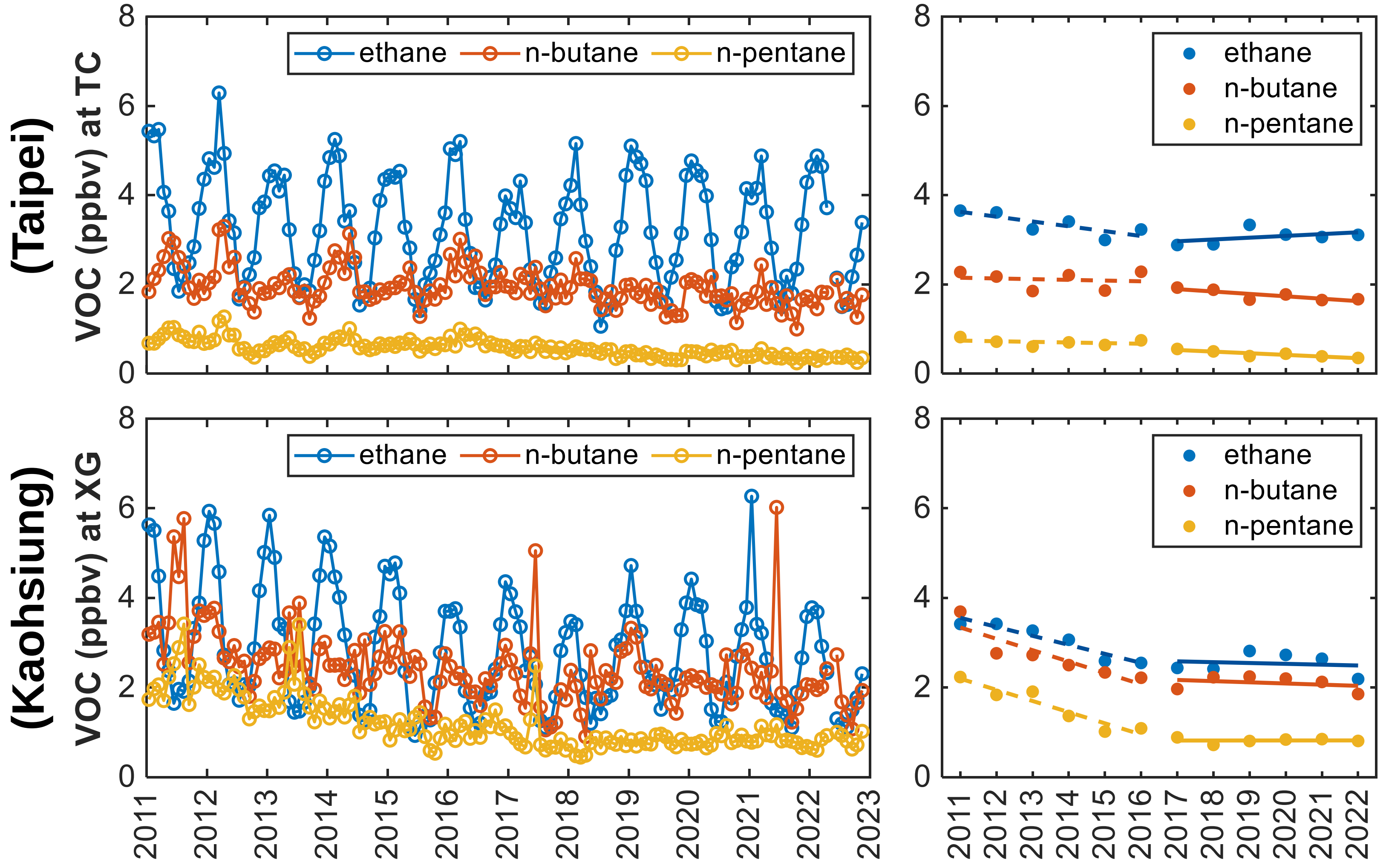


GC-dual FID using heart-cut technique



Ou-Yang et al., 2020.

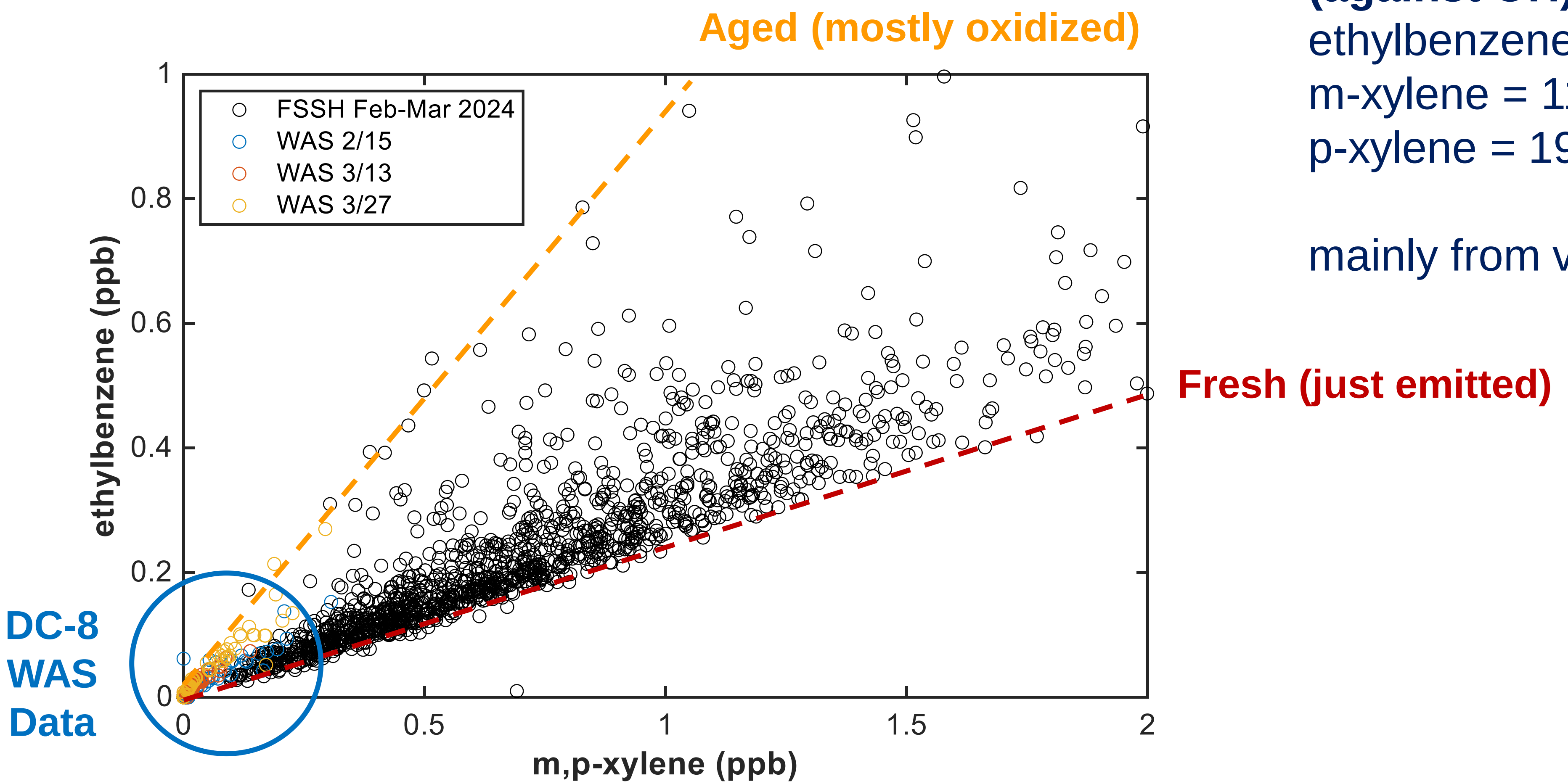
Long-term trends of major alkanes
in Taipei and Kaohsiung



Atmospheric lifetimes (against OH):
ethane = 45 d
n-butane = 4.7 d
n-pentane = 2.9 d

- Significant VOC reduction
- Seasonal variations
- Higher ethane at TC

Photochemical and mixing process
Feb-Mar 2024



Atmospheric lifetimes (against OH):

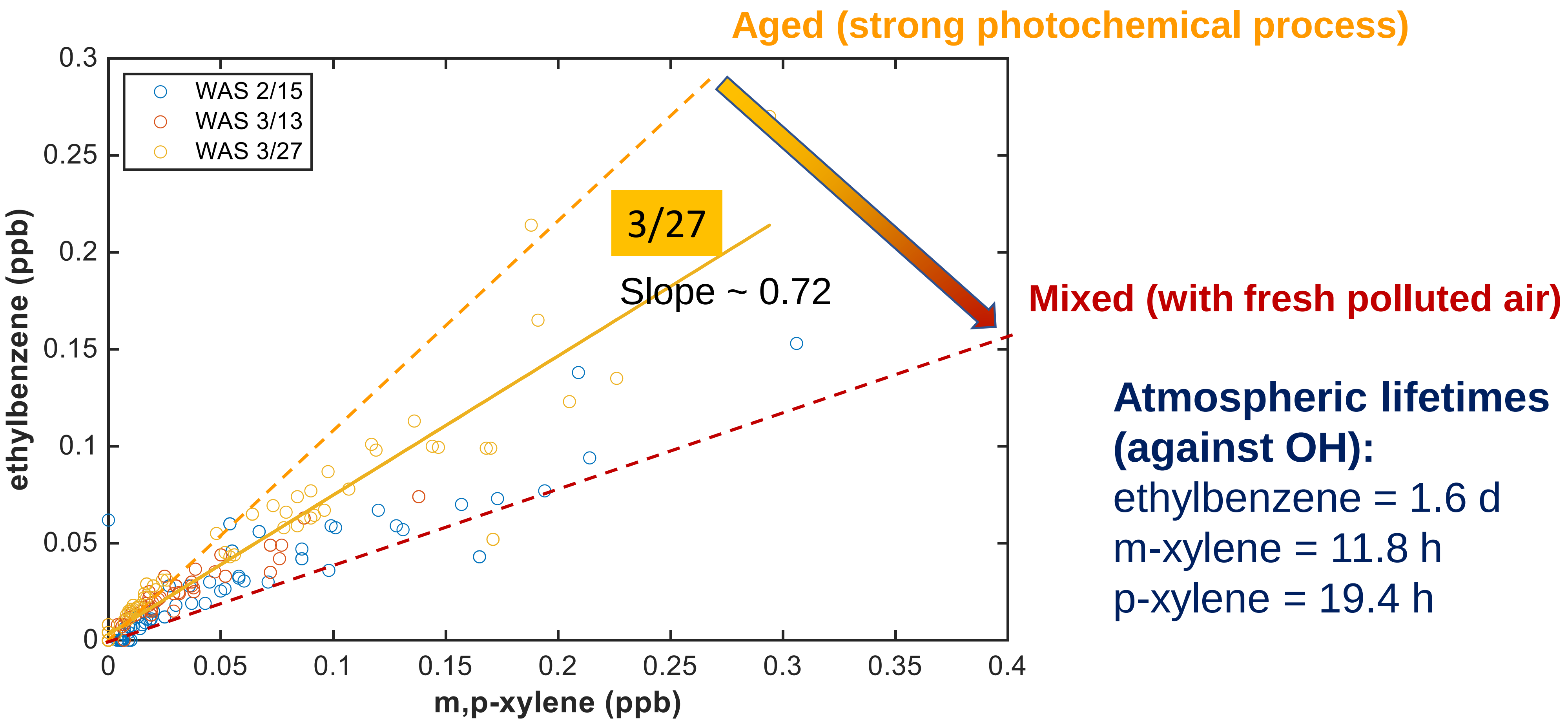
ethylbenzene = 1.6 d

m-xylene = 11.8 h

p-xylene = 19.4 h

mainly from vehicle exhaust

Influences of mixing



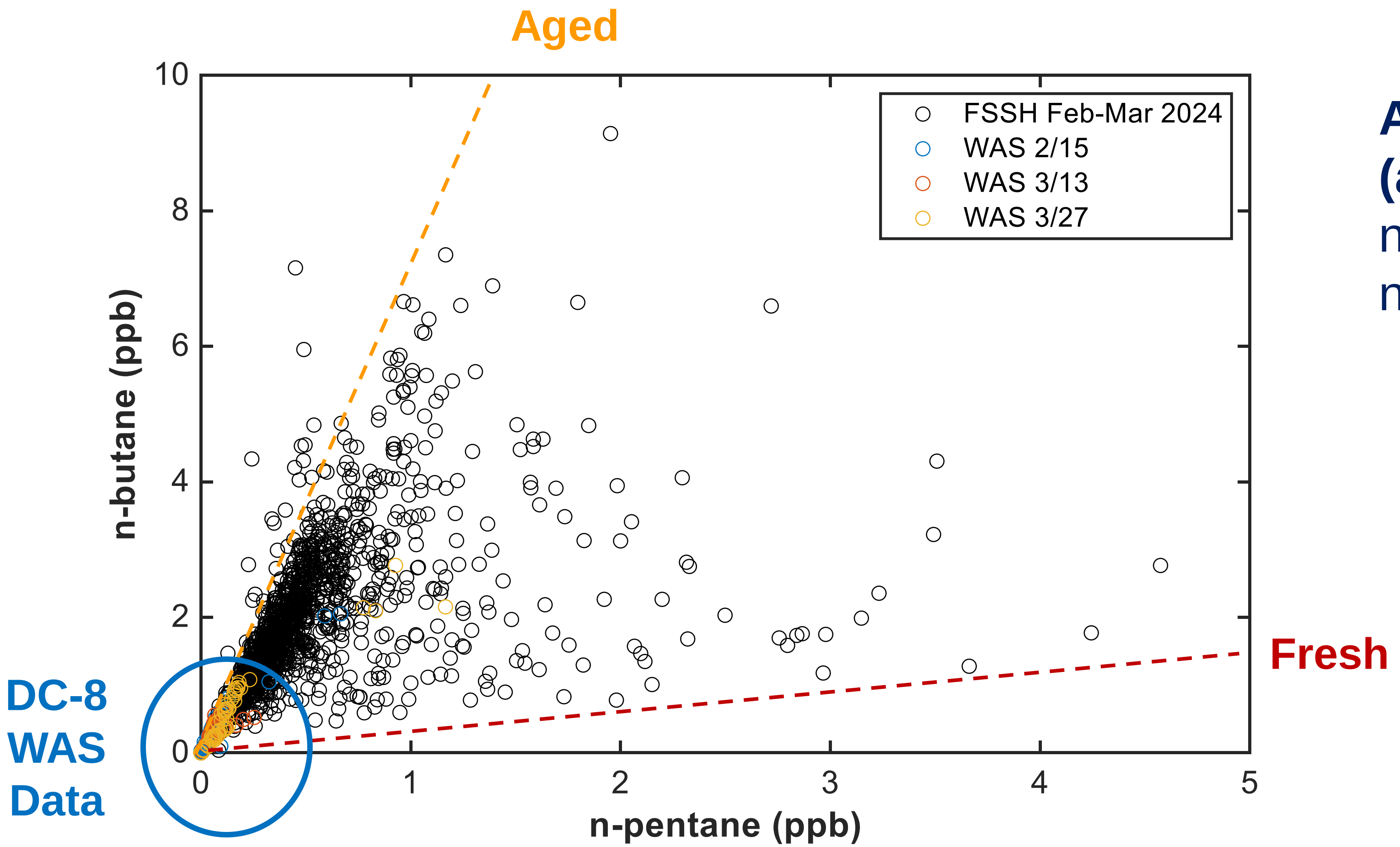
Atmospheric lifetimes (against OH):

ethylbenzene = 1.6 d

m-xylene = 11.8 h

p-xylene = 19.4 h

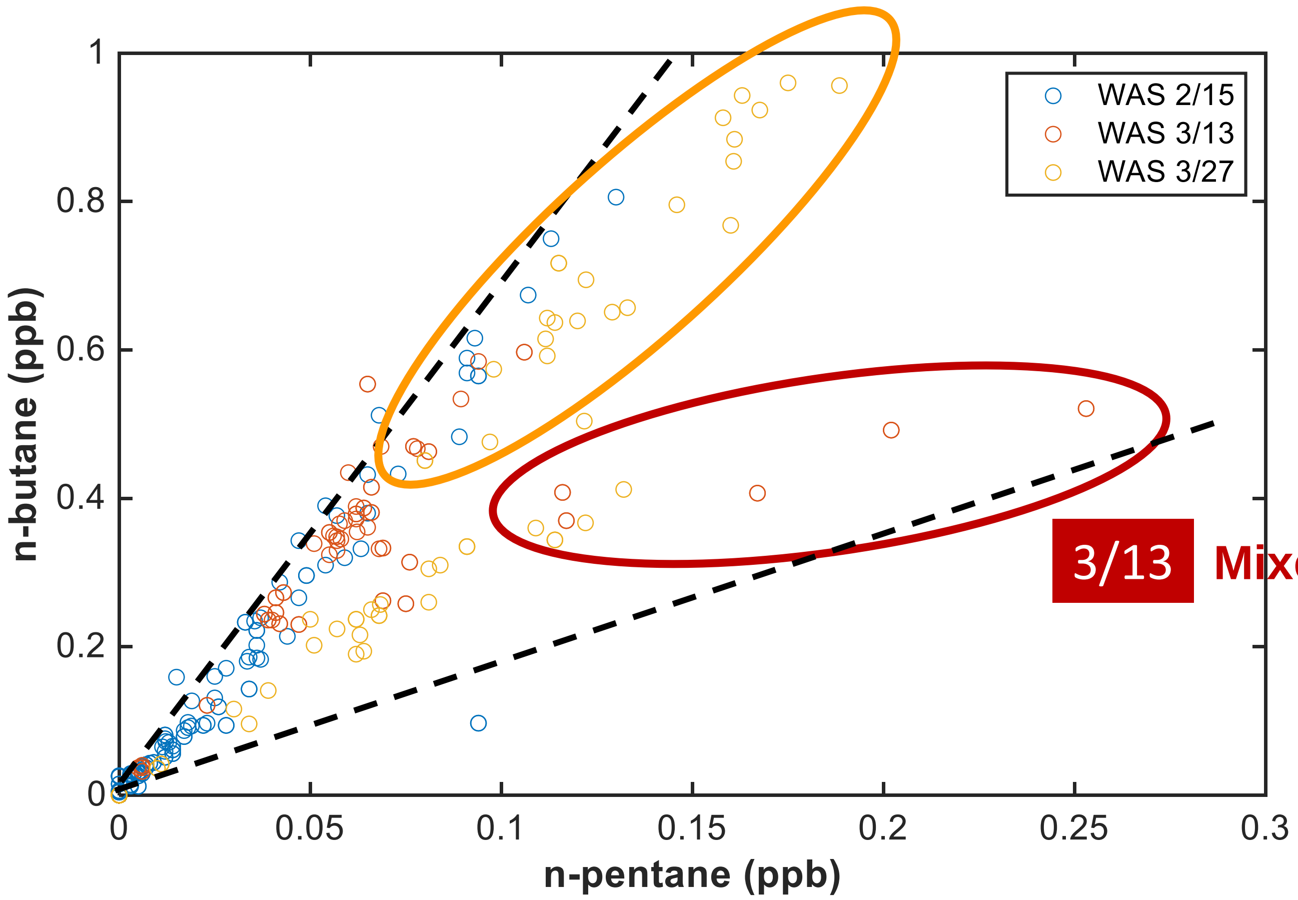
VOCs with longer lifetimes



Atmospheric lifetimes (against OH):
n-butane = 4.7 d
n-pentane = 2.9 d

Aging and mixing

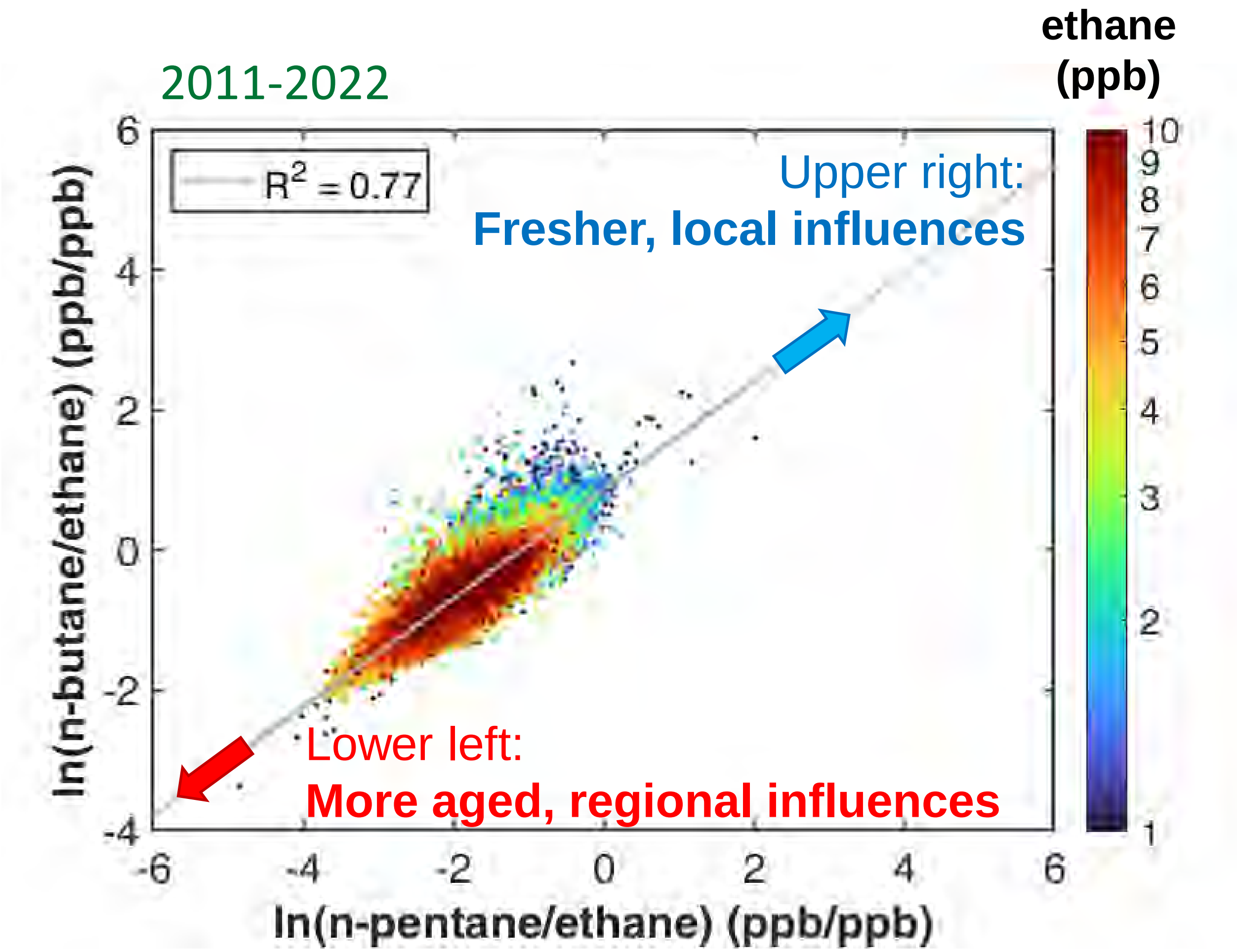
3/27 Strong photochemical process



3/13 Mixed with local emissions

Atmospheric lifetimes (against OH):
n-butane = 4.7 d
n-pentane = 2.9 d

VOC ratio pair at TC (Taipei)
(n-butane/ethane) & (n-pentane/ethane)

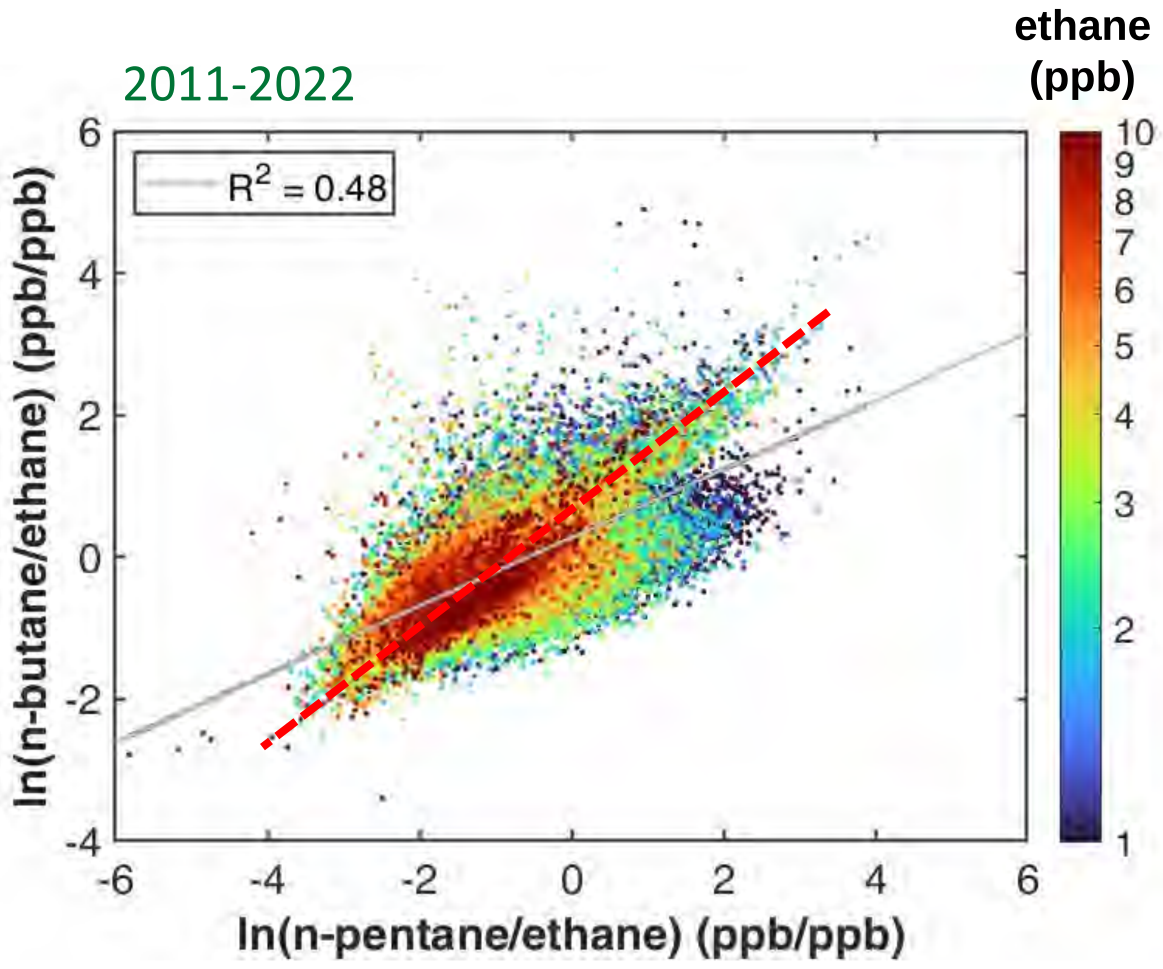


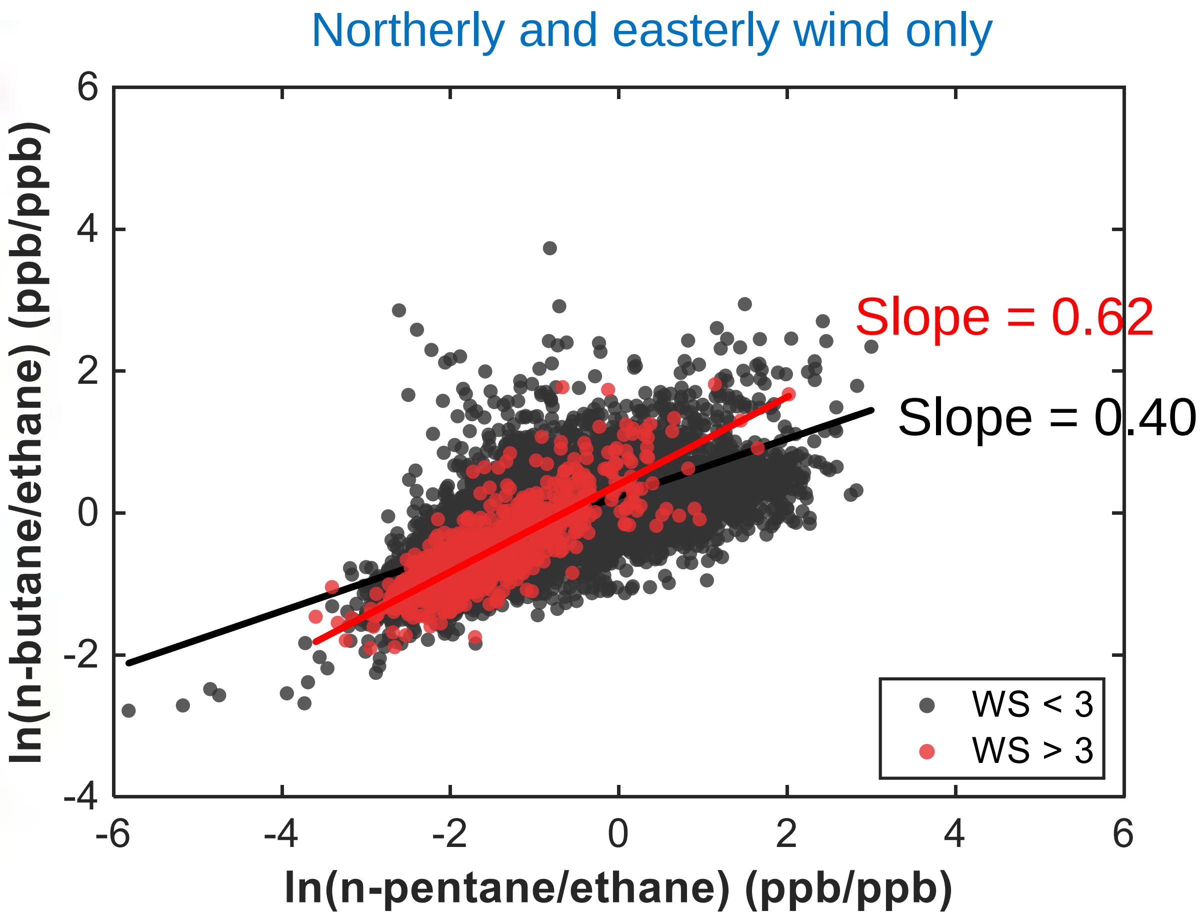
Implications/benefits:

1. Eliminate the differences between various instruments
2. Indication of aging and mixing condition of air masses measured
3. Increased ethane events located at lower left in the plot, indicating they are aged and likely from transboundary pollution (NE monsoon in winter).

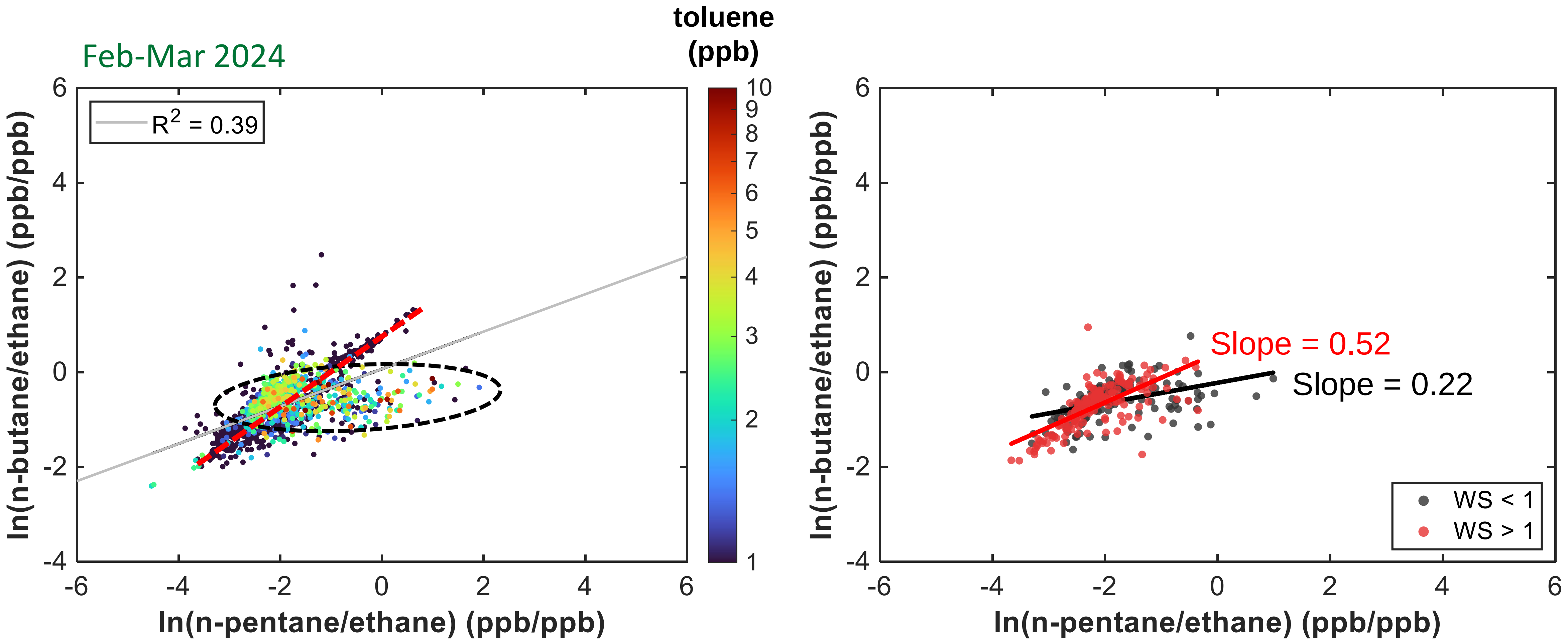
Ou-Yang et al., 2020.

VOC ratio pair at XG (Kaohsiung)
(n-butane/ethane) & (n-pentane/ethane)





XG during ASIA-AQ/KPEx (Feb-Mar, 2024)
(n-butane/ethane) & (n-pentane/ethane)



Summary

- UAV data quality can be validated by CFCs
- Vertical features are the result of interplay between emissions and atmospheric dynamics
- VOC pairs are used to reveal the photochemical and mixing atmospheric condition.
- With VOC pairs coupling to wind data, regional and local influences at XG or FSSH can be distinguished for specific VOC.

Contact: cfouyang@cc.ncu.edu.tw

ASIA-AQ 2025 Science Team Meeting

Chemical mass closure and sources of hourly $PM_{2.5}$ in southern Taiwan during the Kao-Ping Experiment (KPEx)

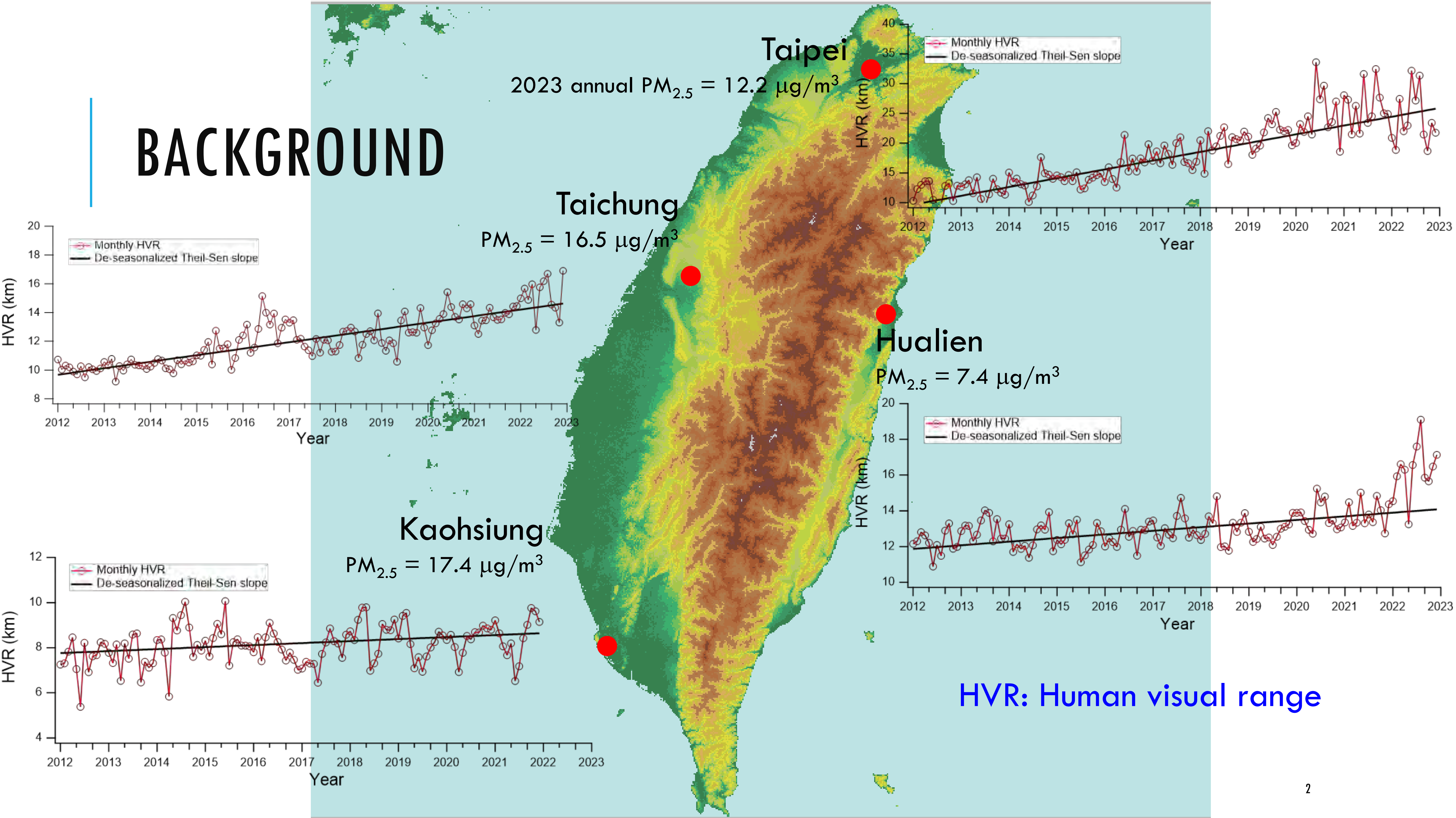
Shi-Ya Tang[1], Li-Hao Young[1,*], Ta-Chih Hsiao[2], Tse-Lun Chen[3], Neng-Huei Lin[4], Si-Chee Tsay[5], Wen-Yinn Lin[6], and the KPEx team

*Correspondence: lhy@mail.cmu.edu.tw

[1]Dept. of Occupational Safety and Health, **China Medical University**, Taichung, Taiwan.
[2]Graduate Inst. of Environmental Engineering, **National Taiwan University**, Taipei, Taiwan.
[3]Inst. of Environmental Engineering, **National Sun Yat-sen University**, Kaohsiung, Taiwan.
[4]Dept. of Atmospheric Sciences, **National Central University**, Taoyuan, Taiwan.
[5]**NASA** Goddard Space Flight Center, Maryland, USA.
[6]Inst. of Environ. Engineering and Management**, National Taipei Univ. of Technology**, Taipei, Taiwan.

UKM, Malaysia
January 20-24, 2025

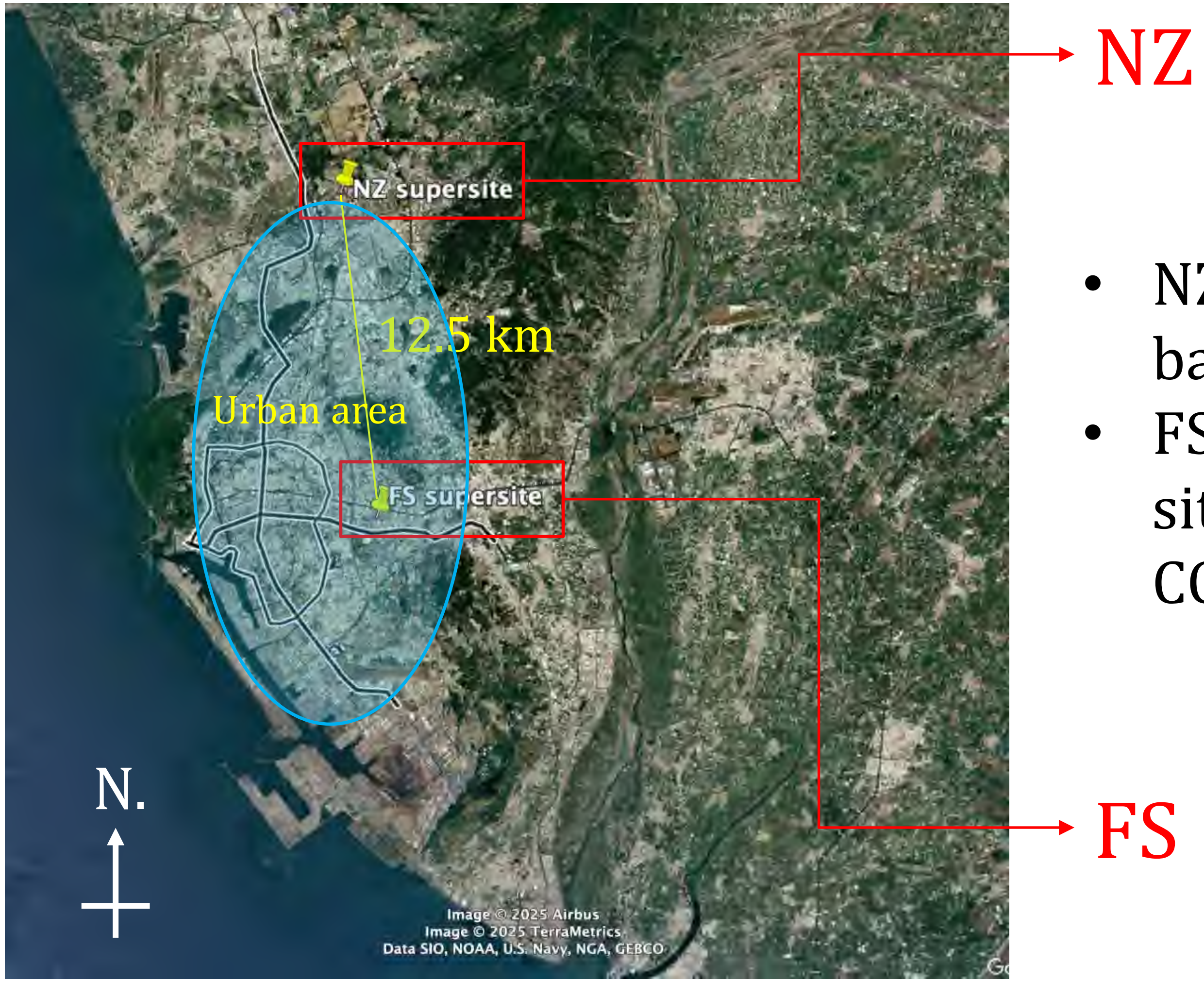
BACKGROUND



HVR: Human visual range

TWO GROUND-BASED SUPERSITES – NZ AND FS

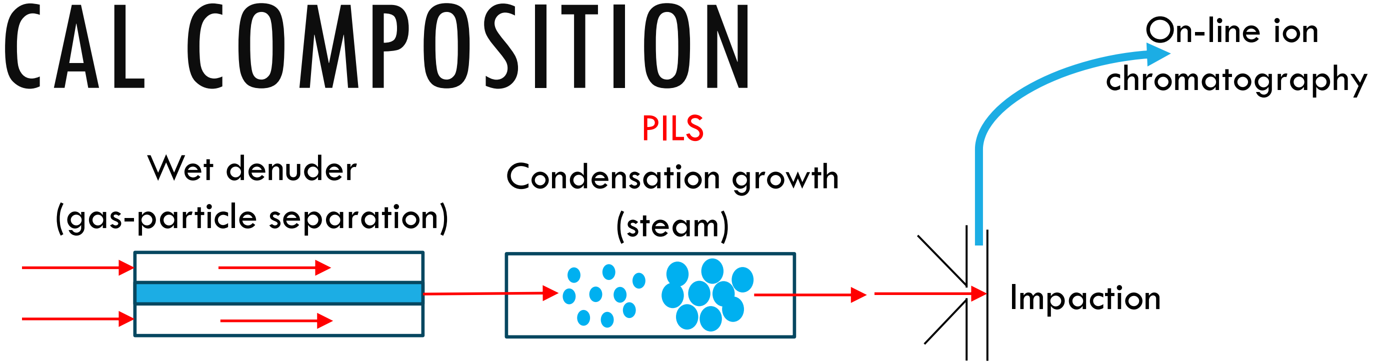
Kaohsiung-Pingtung (KP) in southern Taiwan



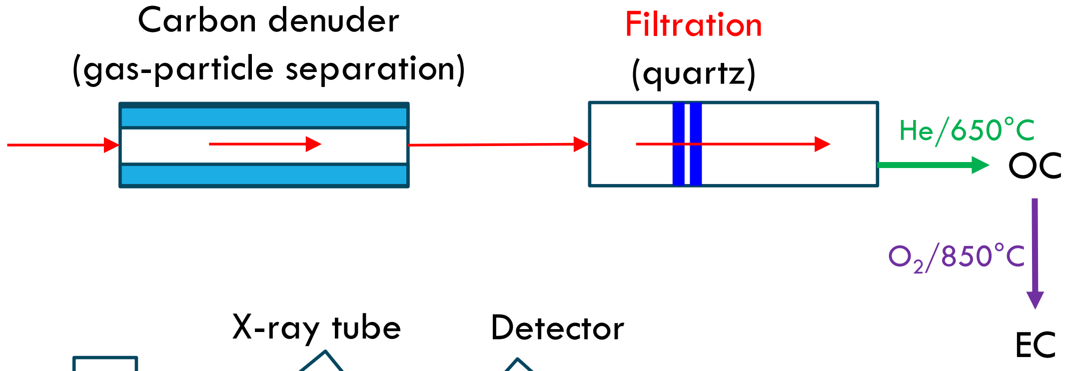
- NZ High School: ground-based site
- FS High School: rooftop site, next to NASA COMMIT trailer

$PM_{2.5}$ HOURLY CHEMICAL COMPOSITION

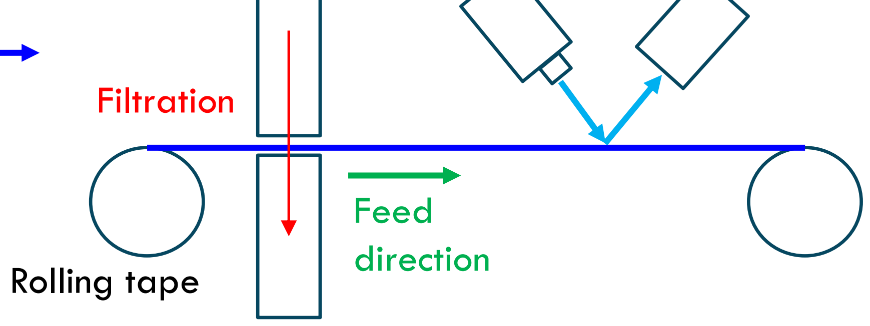
- **Inorganic salts (IGAC)**
  - Zjang Jia Ltd., Taiwan
  - Major: SO_4^{2-}, NO_3^-, NH_4^+
  - Minor: NaCl (sea salt, SS), Ca^{2+}, Mg^{2+}, K^+



- **Carbonaceous matter (Thermo Opt.)**
  - Sunset Lab., USA
  - Organic matter: estimated from OC,
    including secondary/primary OC
  - Elemental carbon (EC)



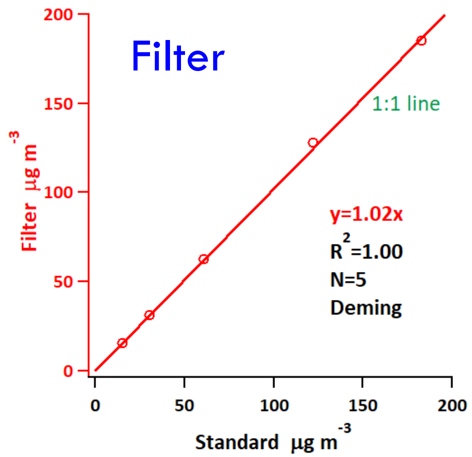
- **Trace/metal elements (XRF)**
  - Sailbri Cooper Inc., USA (43 elements)
  - Crustal: Al, Si, Ca, Fe, Ti
  - Toxic: Cr, As, Se, Hg, Pb

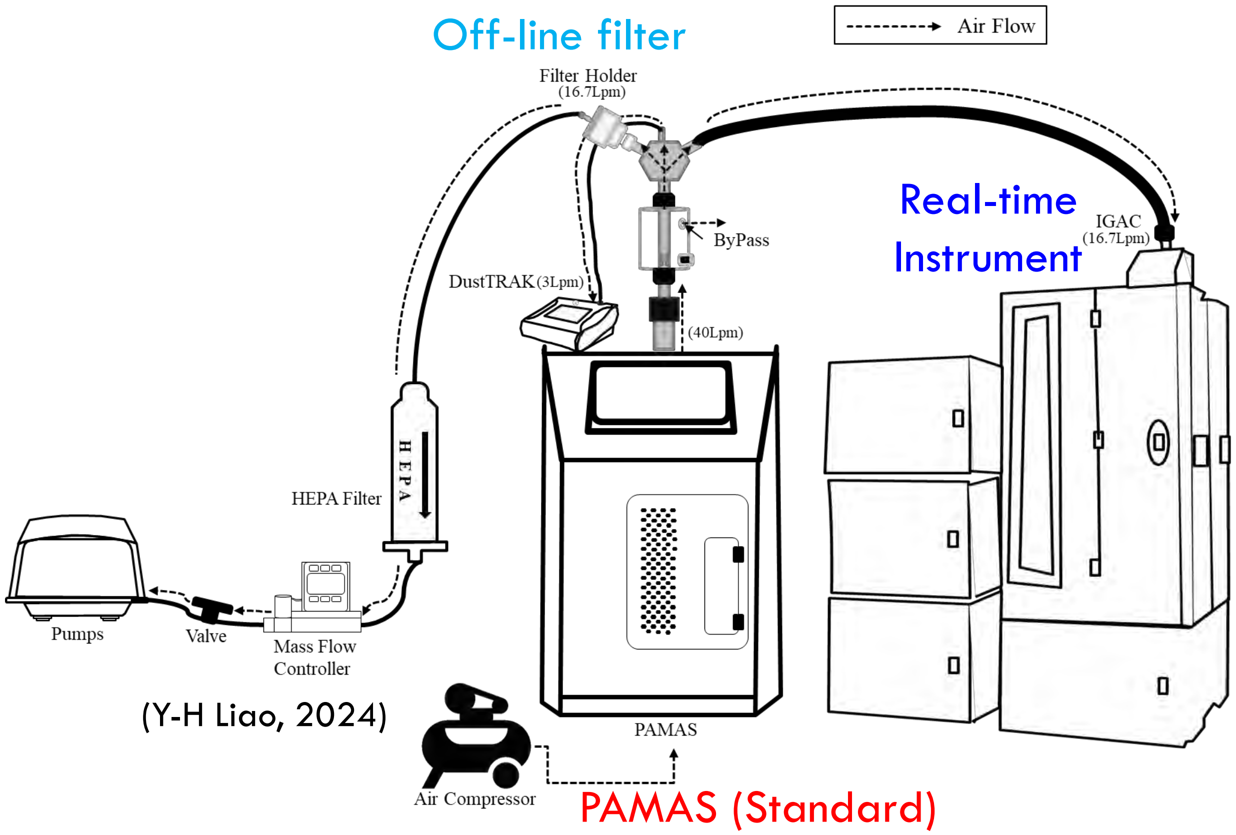


Atmospheric-relevant concentrations

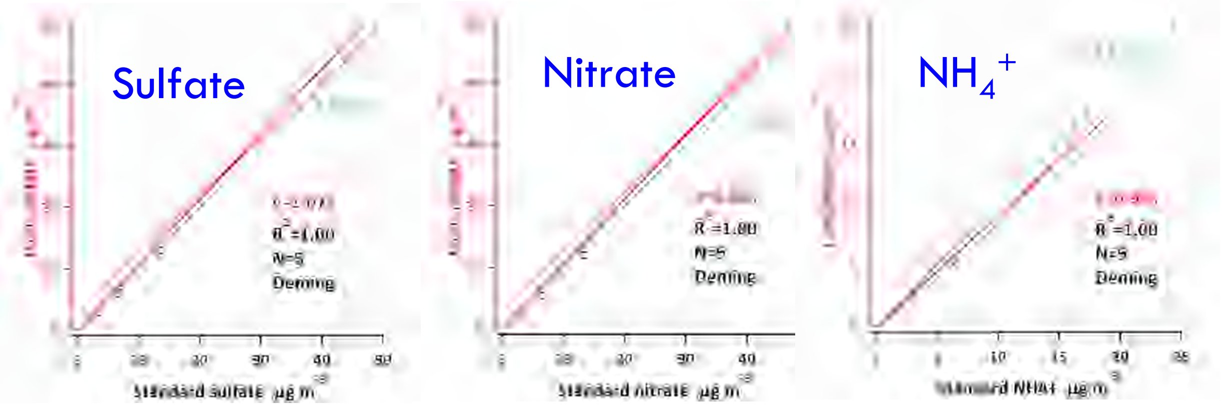
INSTRUMENT QAQC (ON-LINE CALIBRATION)

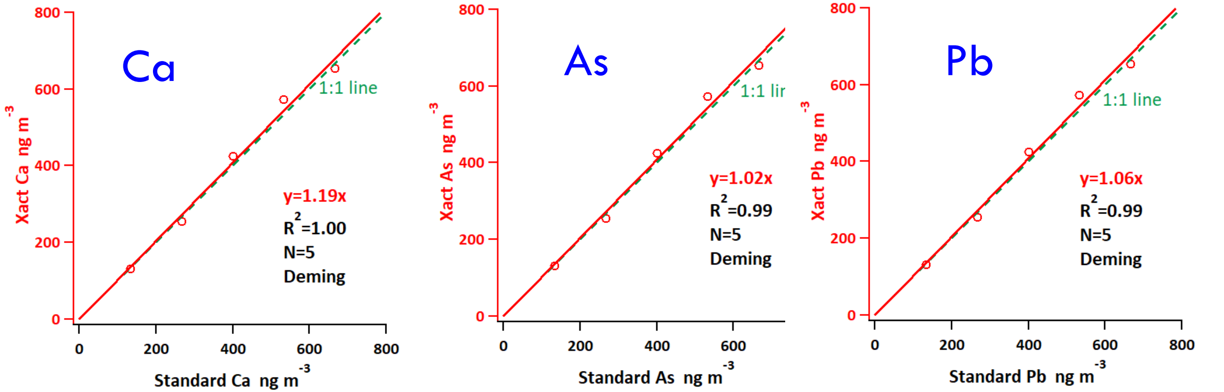
- Primary standard Aerosol MAss calibration System (PAMAS)
  - Commercialized by Zjang Jia Ltd. (https://www.zj-env.com/home.jsp)
  - Online calibration of IGAC and Xact (to be extended to **OC/EC**)





(Y-H Liao, 2024)

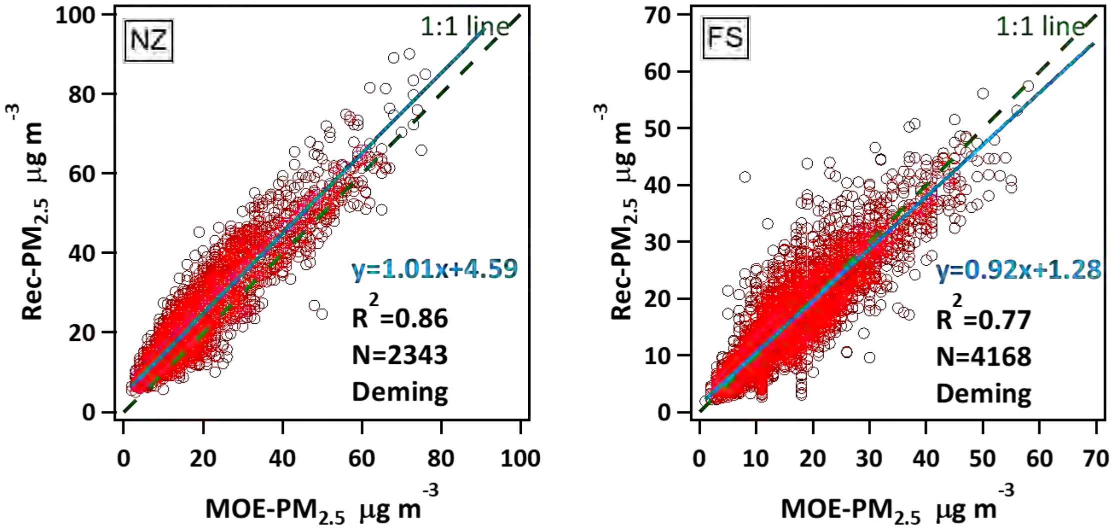




$PM_{2.5}$ CHEMICAL MASS RECONSTRUCTION

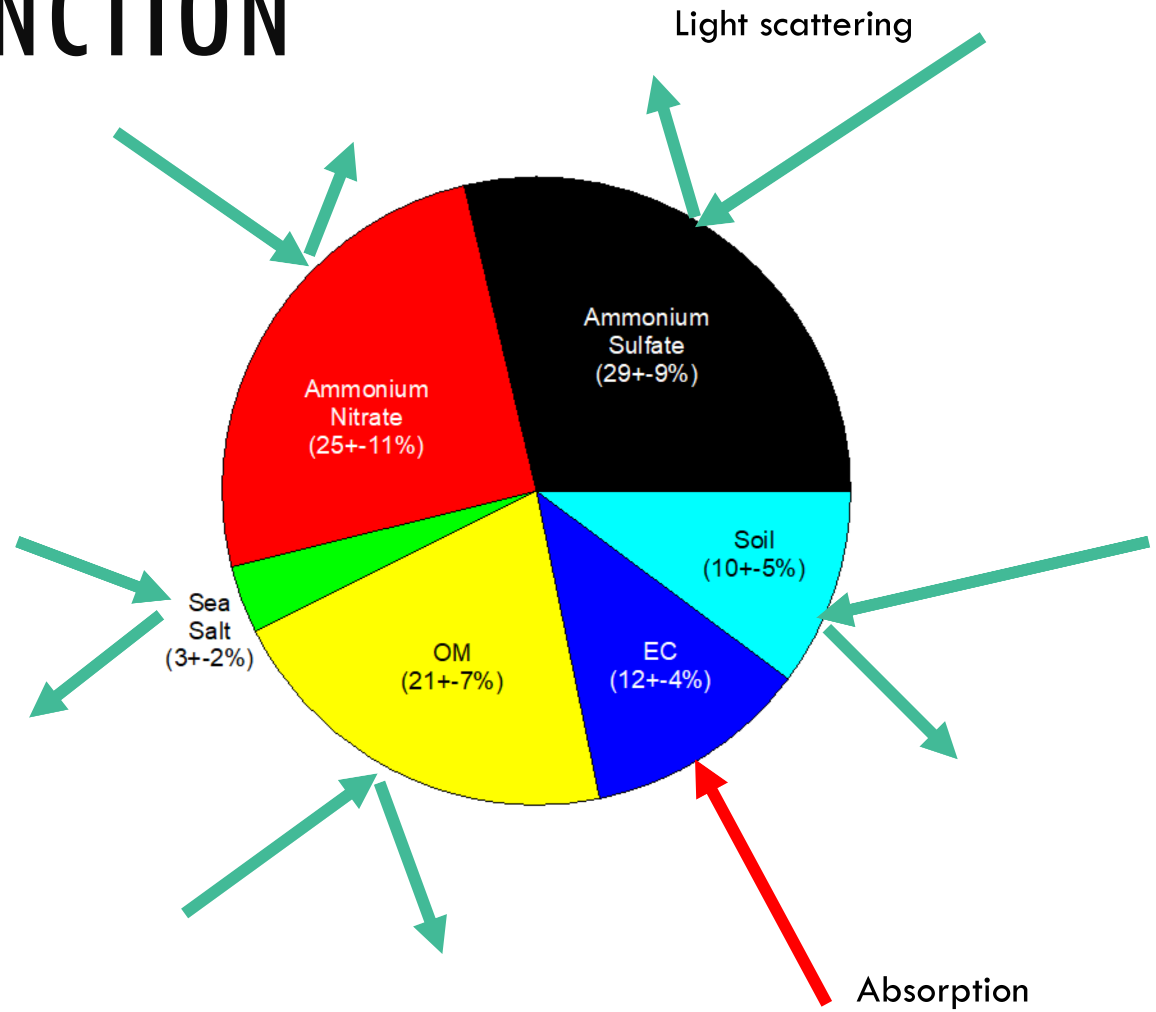
- **Rec. $PM_{2.5}$ = [AS]+[AN]+[SS]+[OM]+[EC]+[Soil]**
  - Compare and validate with MOEnv $PM_{2.5}$ mass monitor (β gauge)
  - Chemical-specific light extinction and source apportionment
- IGAC: **Inorganic salts** = [AS]+[AN]+[SS]
  - Other minor ions ignored
- OC/EC: **Carbonaceous matter** = [OC]×CF+[EC] =[OM]+[EC]
  - CF: conversion factor (1.6)
  - Minimum R^2 method: POC, SOC
- Xact: **[Soil]** = [Al, Si, Ti, Ca, Fe] or [Ti]
  - Others are used in source apportionment

AS: ammonium sulfate
AN: ammonium nitrate
SS: sea salt
OM: organic matter
OC: organic carbon
EC: elemental carbon
POC: primary OC
SOC: secondary OC

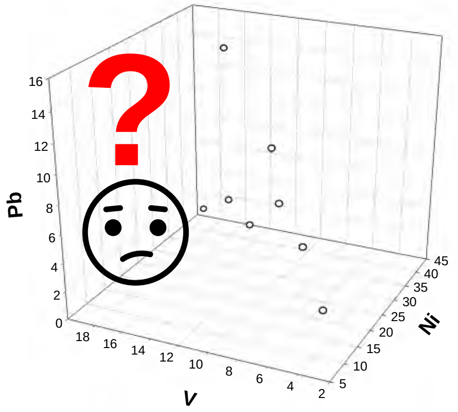


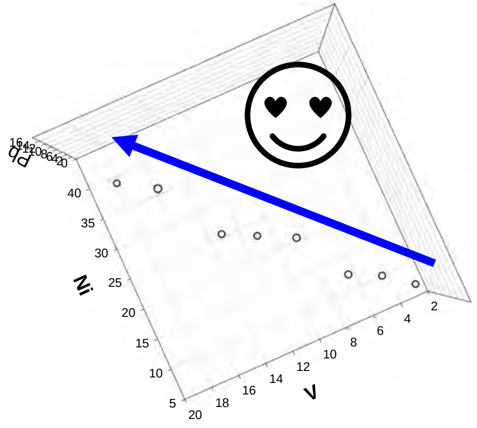
$PM_{2.5}$ CHEMICAL LIGHT EXTINCTION

- $b_{ext}=b_{sp}+b_{ap}+b_{sg}+b_{ag}$
  - sp: particle light scattering
  - ap: particle light absorption
  - sg: gas light scattering
  - ag: gas light absorption
- **b_{sp}** = USEPA IMPROVE revised algorithm
- b_{ap} = 10 × [Elemental Carbon]
- b_{sg} = 11.4 × $(^{293}/_{T})$ × P
- b_{ag} = 0.33 × $[NO_2]$



PM$_{2.5}$ SOURCE APPORTIONMENT





Positive matrix factorization (PMF)

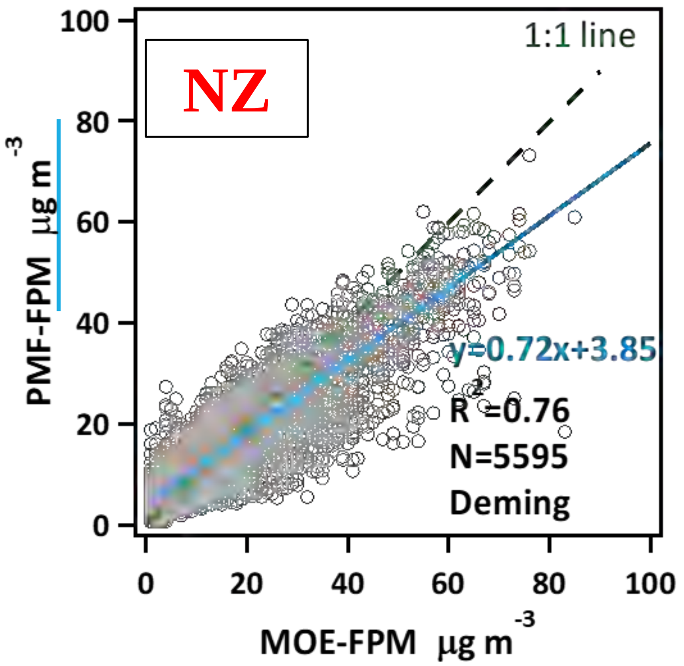
X (Conc. matrix) = **G (Factor contribution)** × **F (Species profile)** + **E (Error)**

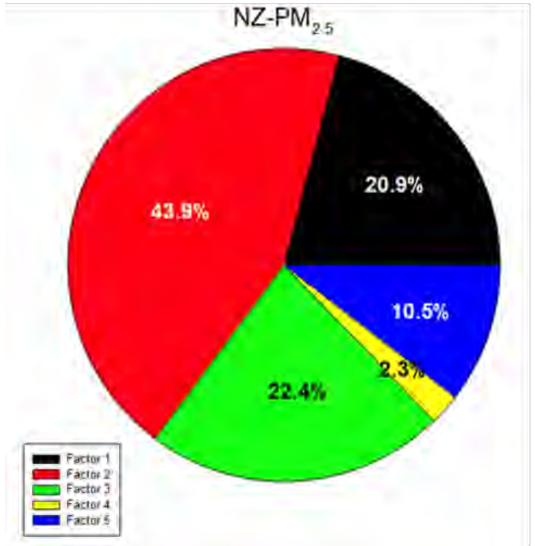
- X: Species (j) × Sample (i): j × i
- G: Factor (k) × Sample (i): k × i
- F: Species (j) × Factor (k): j × k
- E

Source contribution (G)

Source identification (F)

FPM stands for $PM_{2.5}$





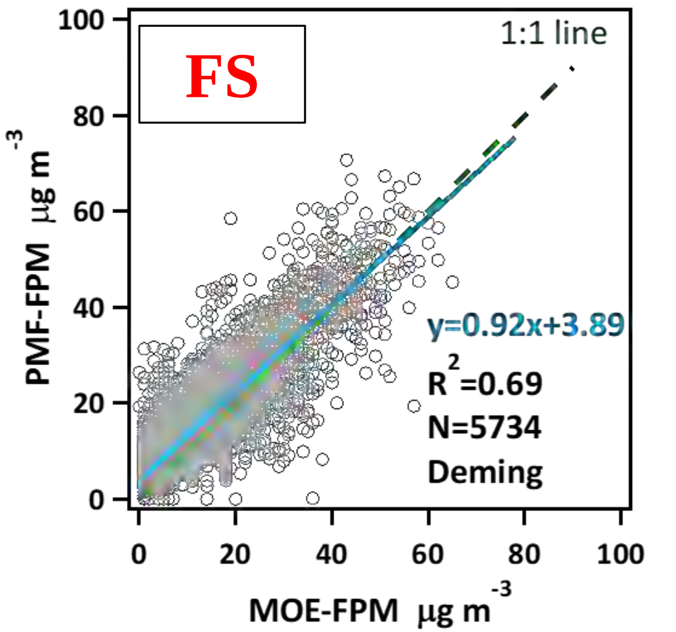
F1: Traffic emission/brake wear (20.9%)

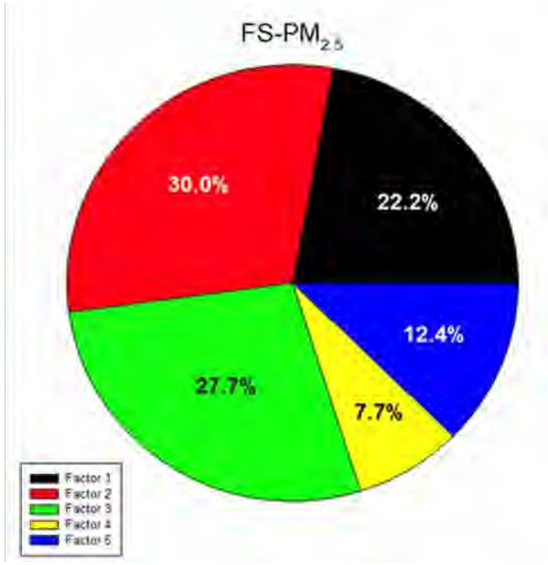
F2: Secondary nitrate/**SOC**/biomass burning (43.9%)

F3: Oil combustion (Sulfate) (22.4%)

F4: Road dust (2.3%)

F5: Industrial emission/coal combustion (10.5%)





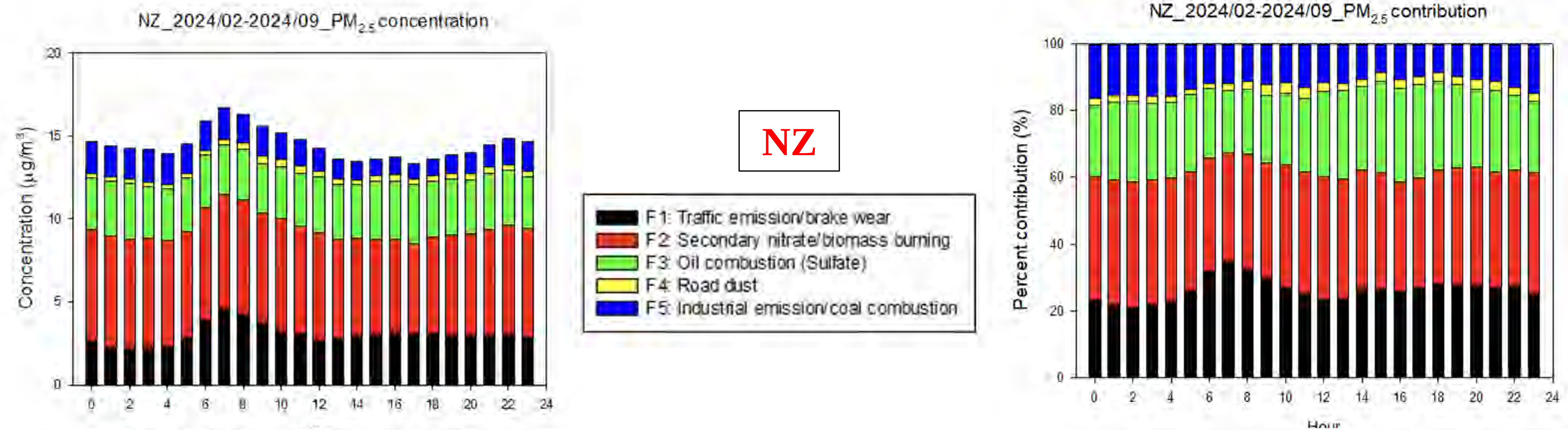
F1: Traffic emission/**POC**/ brake wear/coal combustion (22.2 %)

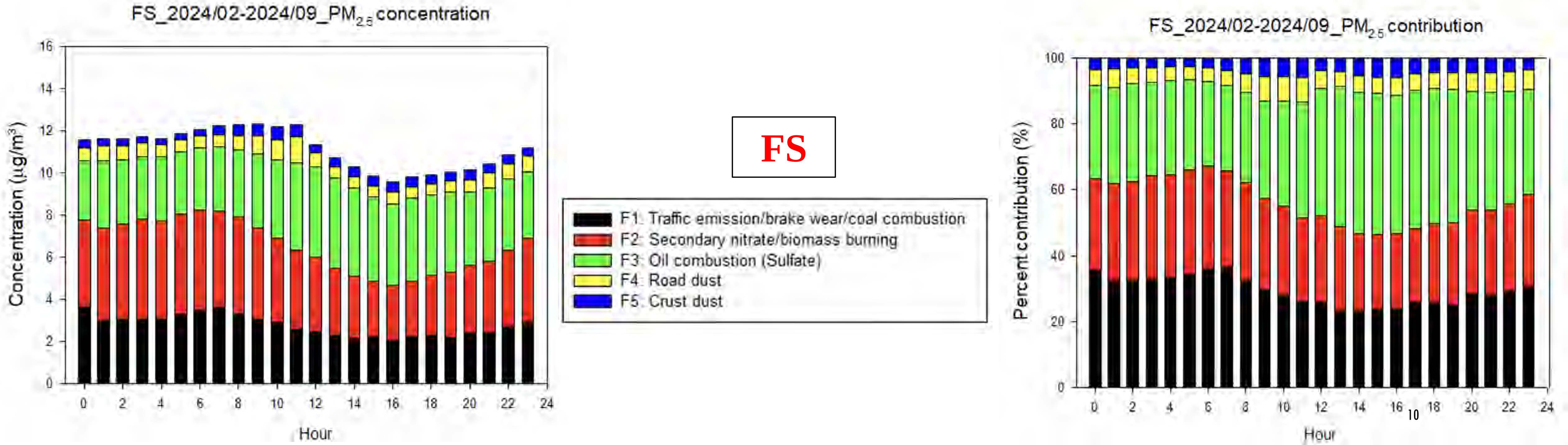
F2: Secondary nitrate/biomass burning (30 %)

F3: Oil combustion (Sulfate) (27.7 %)

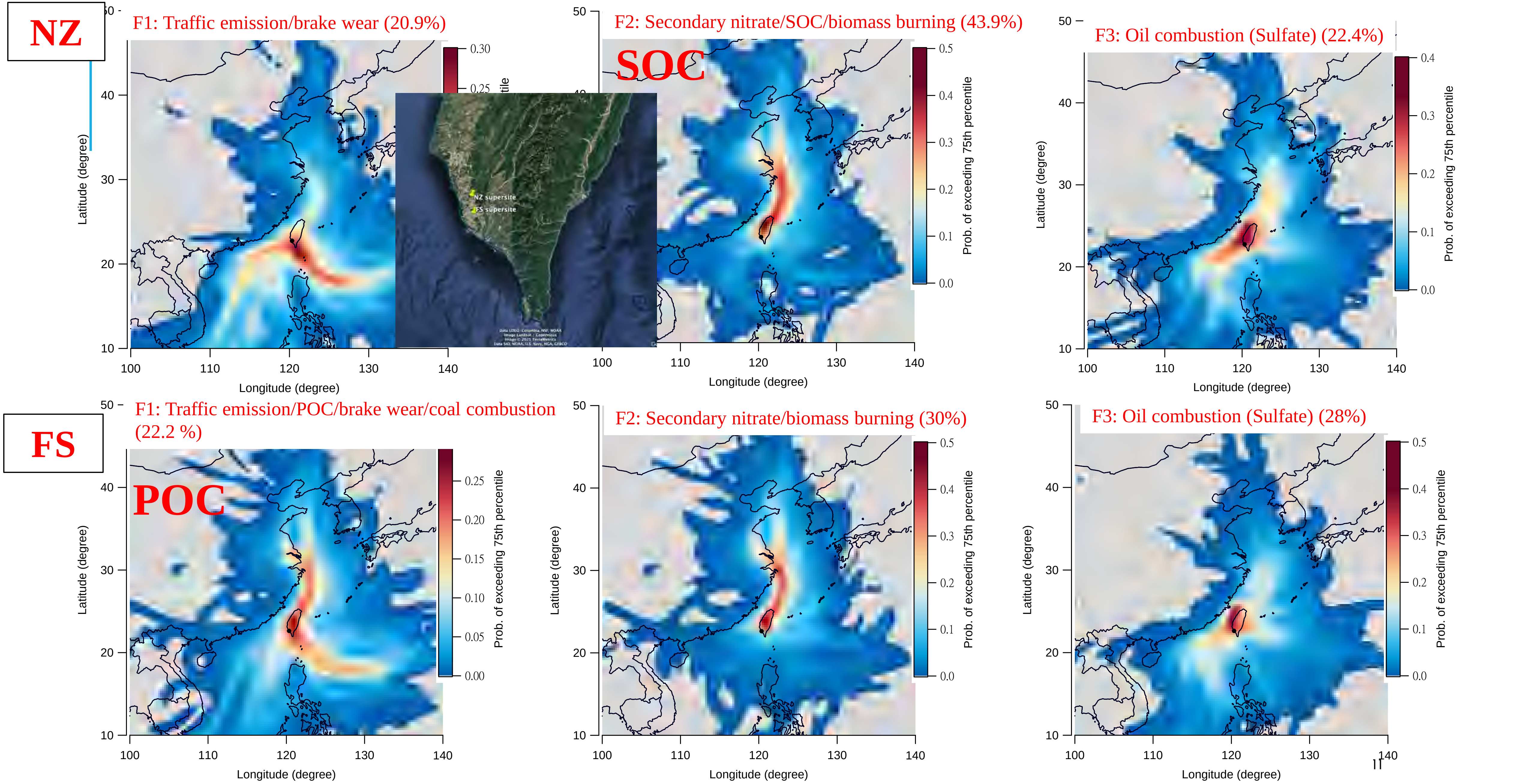
F4: Road dust (7.7 %)

F5: Crust dust (12.4 %)

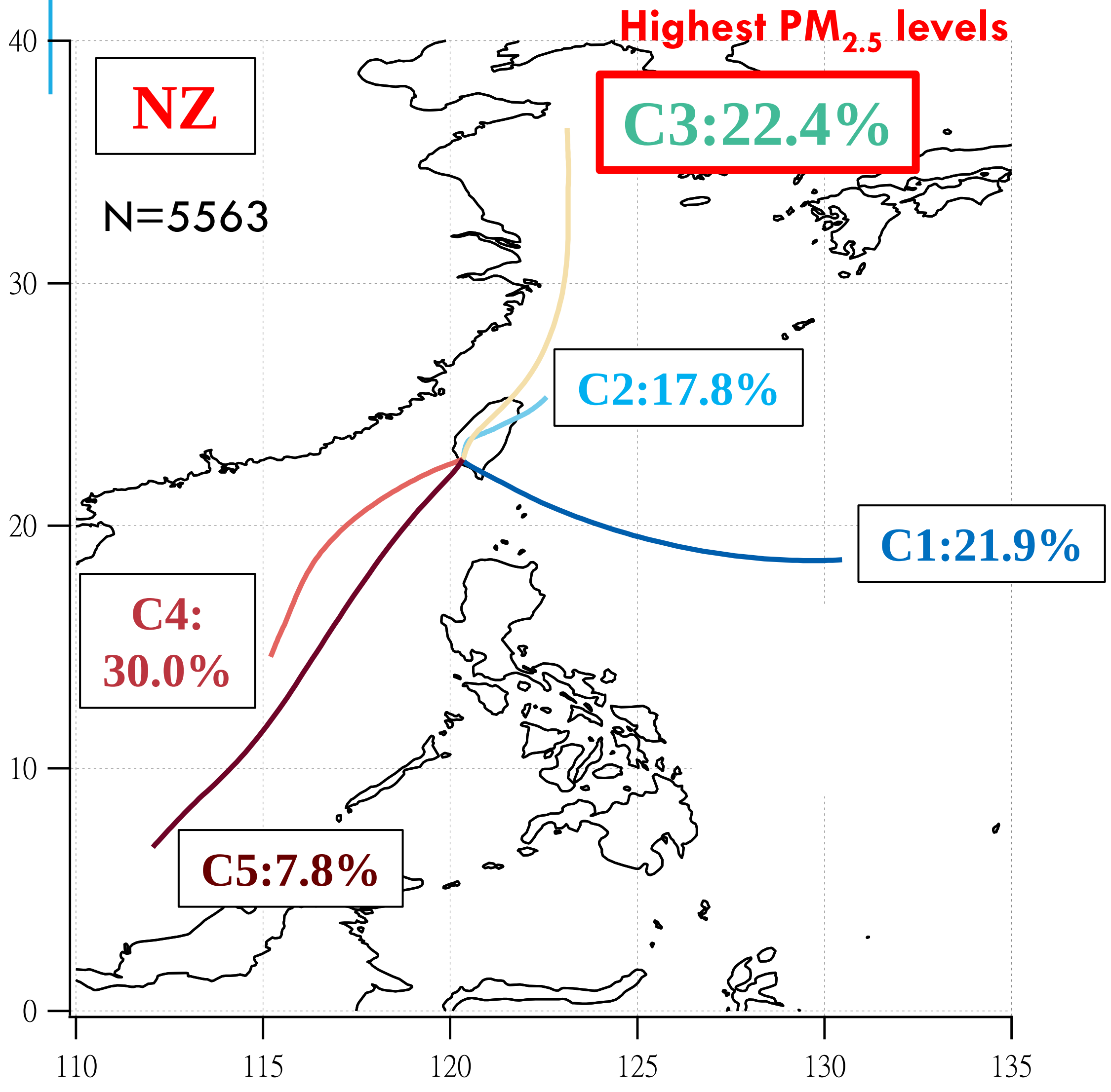

NZ_2024/02-2024/09_PM2.5 concentration
Concentration (μg/m3)
NZ
F1: Traffic emission/brake wear
F2: Secondary nitrate/biomass burning
F3: Oil combustion (Sulfate)
F4: Road dust
F5: Industrial emission/coal combustion
NZ_2024/02-2024/09_PM2.5 contribution
Percent contribution (%)
Hour

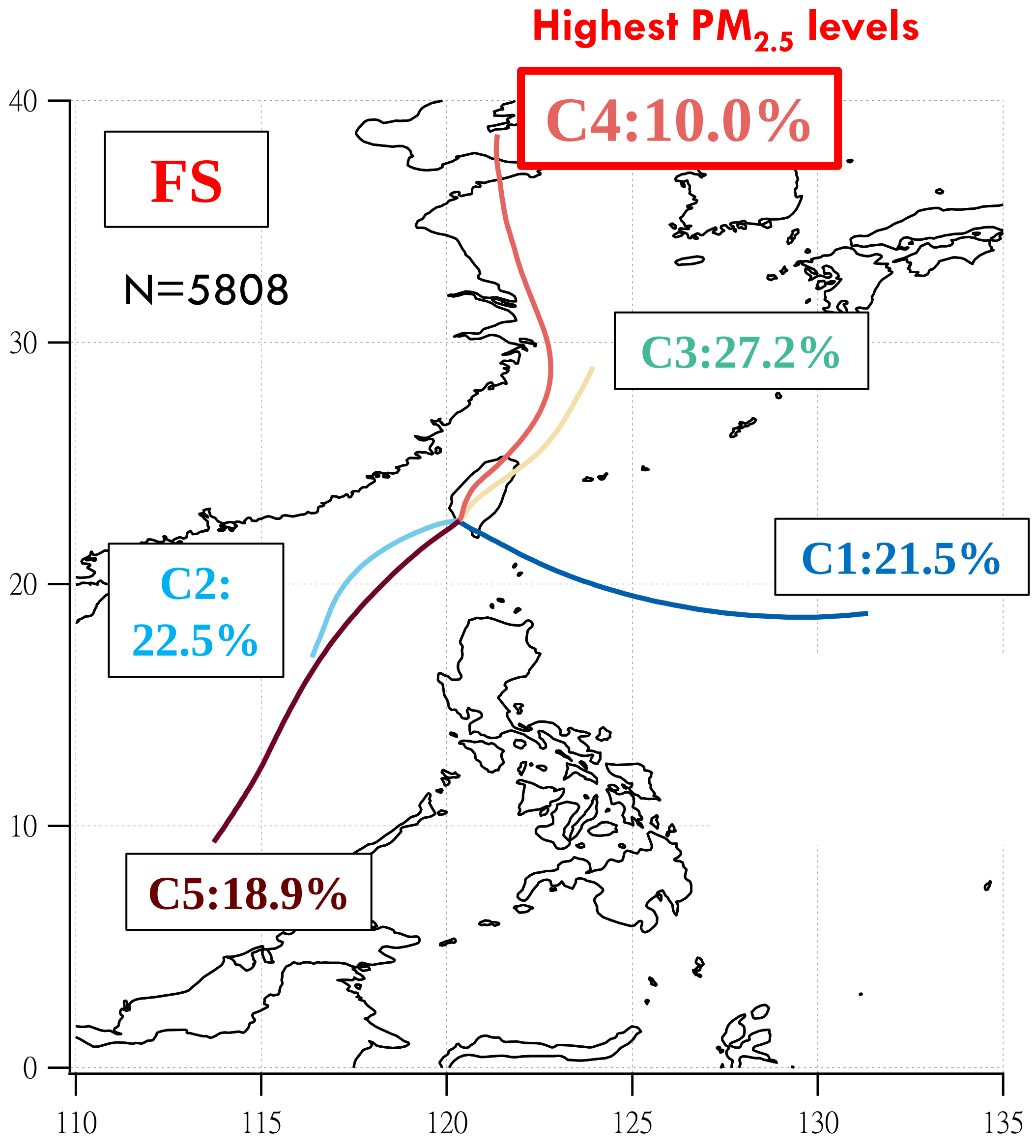

FS_2024/02-2024/09_PM2.5 concentration
Concentration (μg/m3)
Hour
FS
F1: Traffic emission/brake wear/coal combustion
F2: Secondary nitrate/biomass burning
F3: Oil combustion (Sulfate)
F4: Road dust
F5: Crust dust
FS_2024/02-2024/09_PM2.5 contribution
Percent contribution (%)
Hour

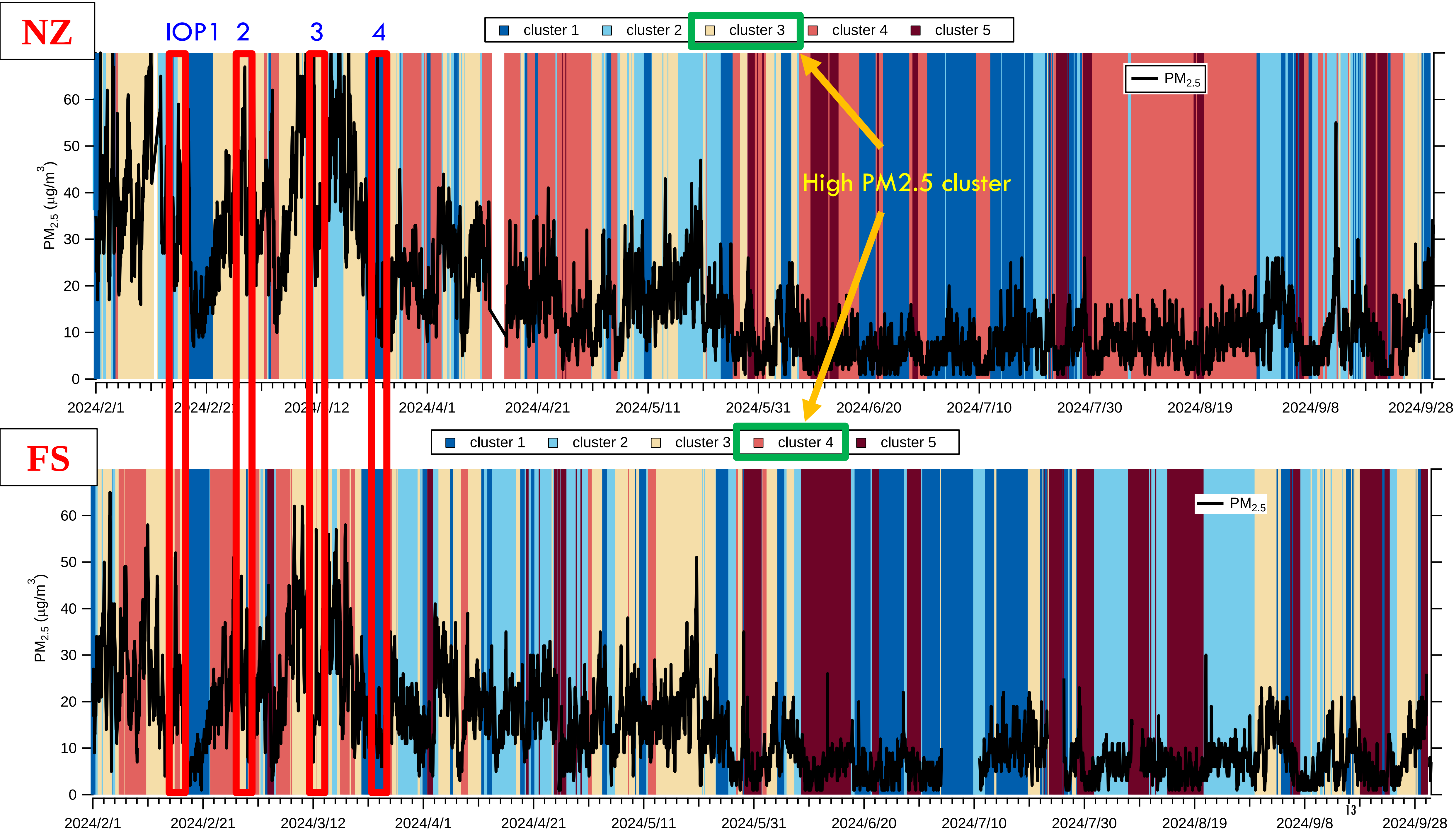
TOP 3 SOURCES



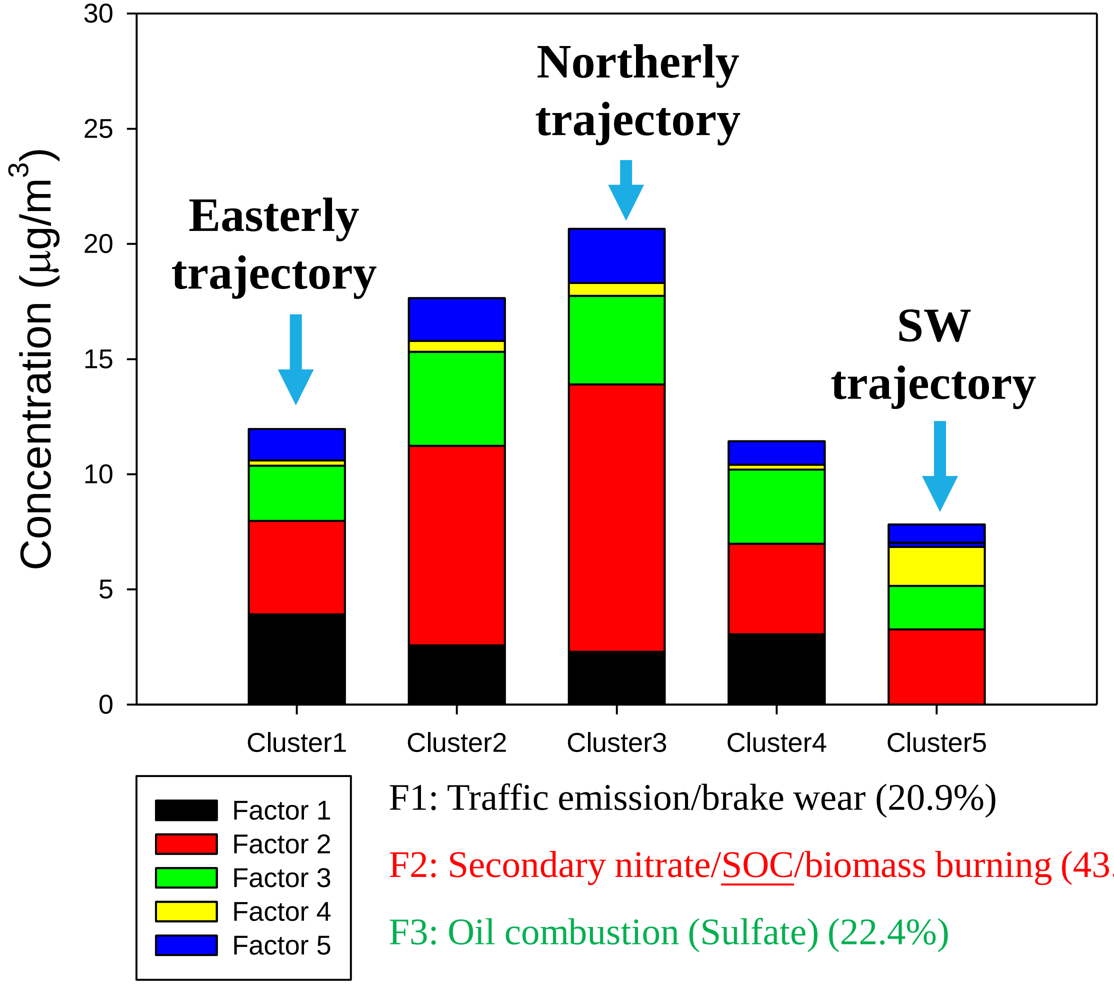
AIRMASS TRAJECTORY CLUSTERS



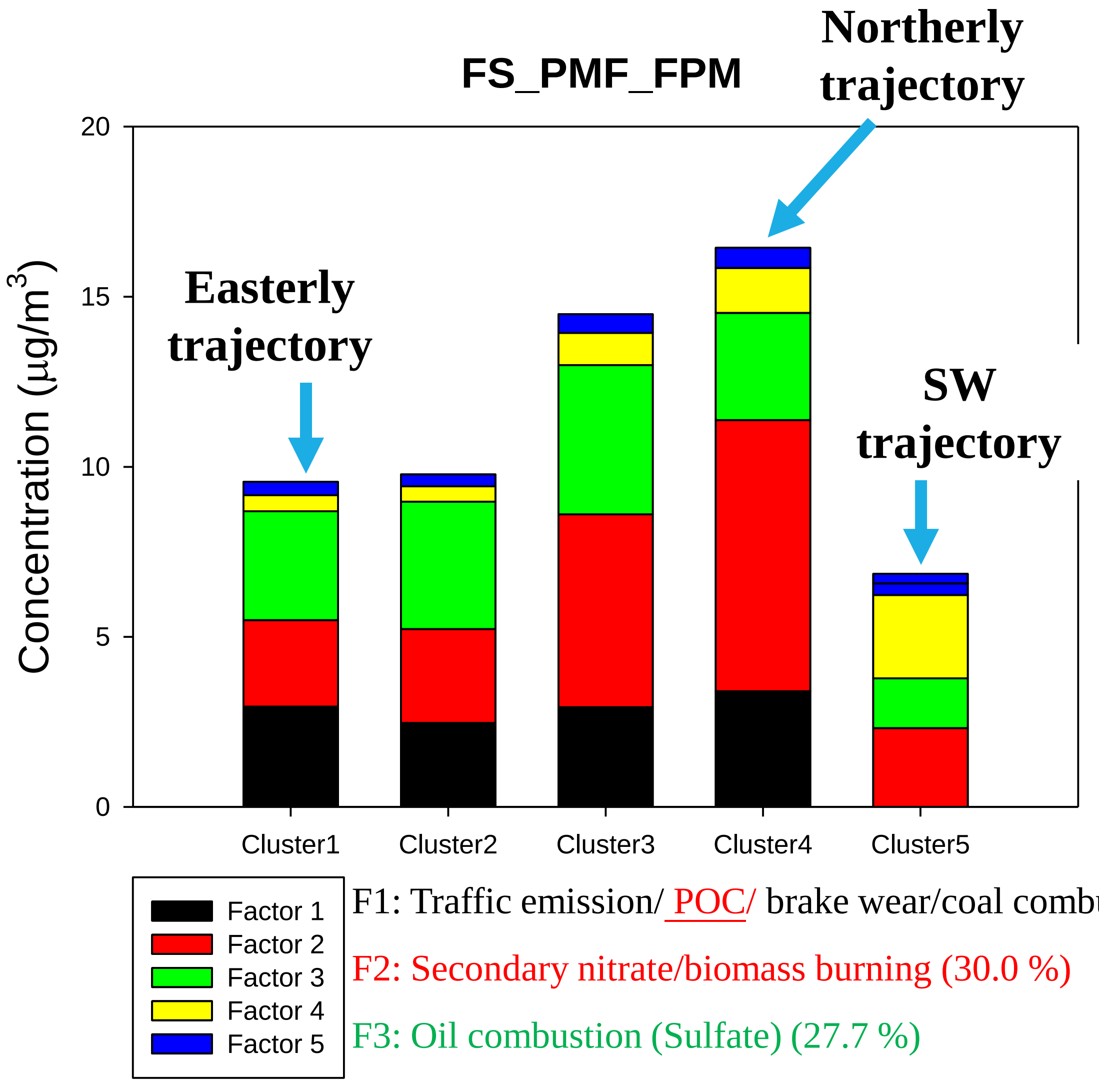



NZ
IOP1
2
3
4
cluster 1
cluster 2
cluster 3
cluster 4
cluster 5
PM2.5
High PM2.5 cluster
PM2.5 (μg/m3)
0
10
20
30
40
50
60
2024/2/1
2024/2/21
2024/3/12
2024/4/1
2024/4/21
2024/5/11
2024/5/31
2024/6/20
2024/7/10
2024/7/30
2024/8/19
2024/9/8
2024/9/28
FS
cluster 1
cluster 2
cluster 3
cluster 4
cluster 5
PM2.5
PM2.5 (μg/m3)
0
10
20
30
40
50
60
2024/2/1
2024/2/21
2024/3/12
2024/4/1
2024/4/21
2024/5/11
2024/5/31
2024/6/20
2024/7/10
2024/7/30
2024/8/19
2024/9/8
2024/9/28

SOURCE CONTRIBUTION BY TRAJECTORY CLUSTER

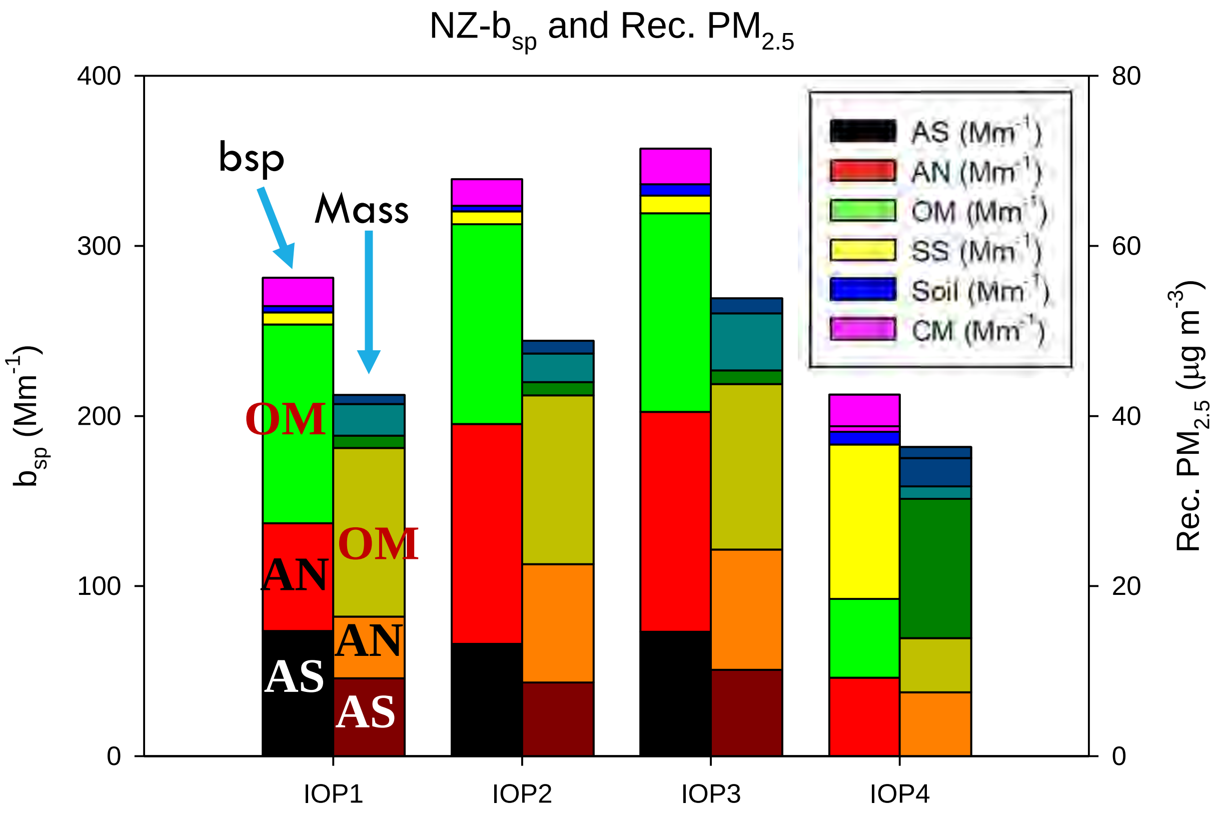


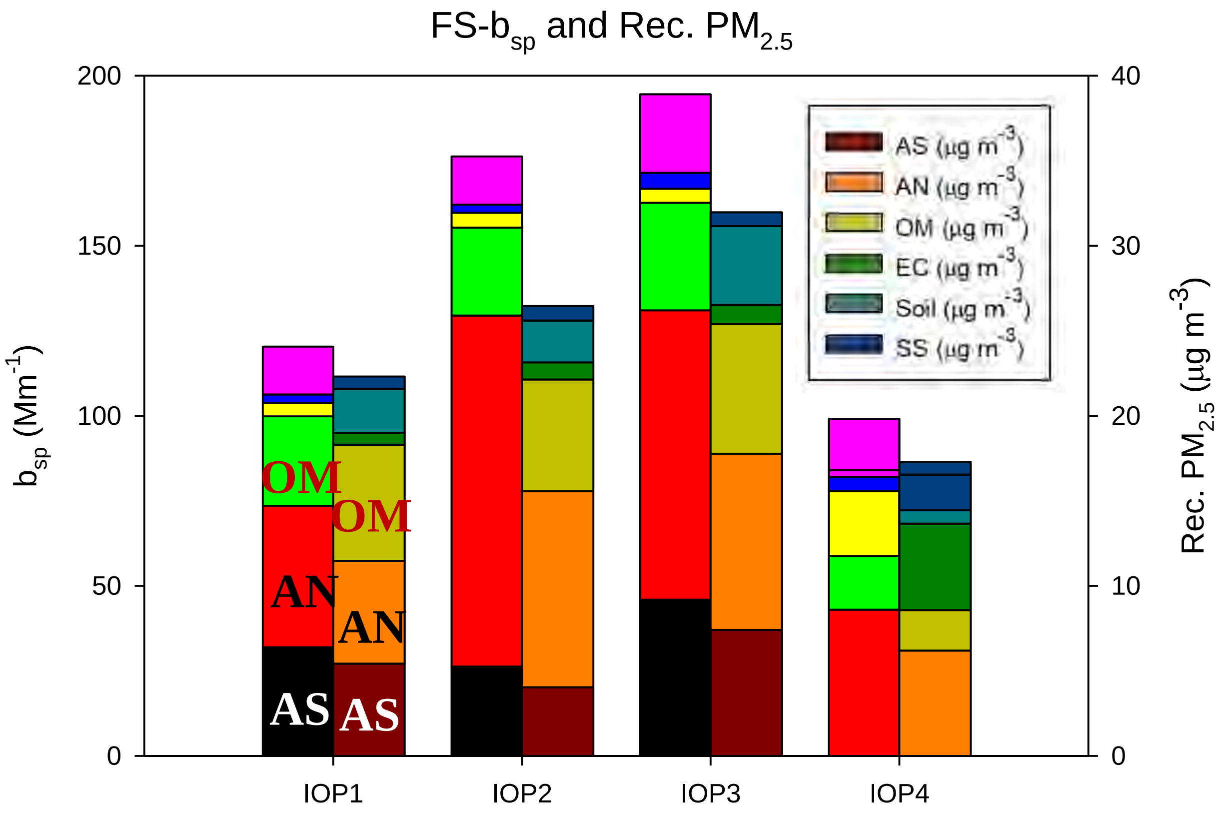
- F1: Traffic emission/brake wear (20.9%)
- F2: Secondary nitrate/SOC/biomass burning (43.9%)
- F3: Oil combustion (Sulfate) (22.4%)
- F4: Road dust (2.3%)
- F5: Industrial emission/coal combustion (10.5%)



- F1: Traffic emission/ POC/ brake wear/coal combustion (22.2 %)
- F2: Secondary nitrate/biomass burning (30.0 %)
- F3: Oil combustion (Sulfate) (27.7 %)
- F4: Road dust (7.7 %)
- F5: Crustal dust (12.4 %)

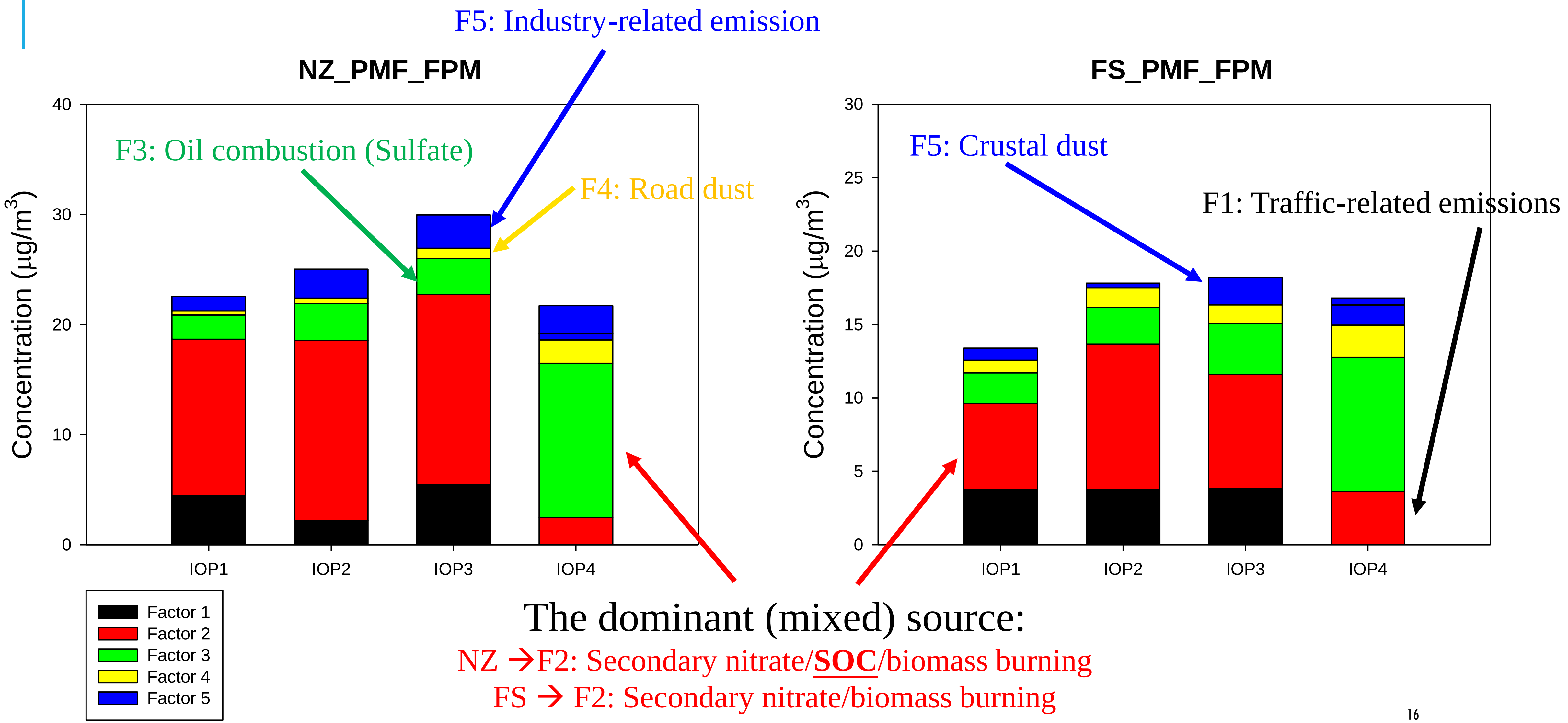
$PM_{2.5}$ LIGHT SCATTERING (b_{sp}) AND MASS DURING IOPs





- The key contributor to $PM_{2.5}$ b_{sp} and mass was OM at NZ, but it was AN/AS at FS.

$PM_{2.5}$ SOURCES DURING IOPs



The dominant (mixed) source:

NZ →F2: Secondary nitrate/**SOC**/biomass burning

FS → F2: Secondary nitrate/biomass burning

SUMMARY (PRELIMINARY) – MORE REFINEMENTS AND CROSS-EVALUATION ARE NEEDED

During KPEx at the two supersites:

- Hourly $PM_{2.5}$ mass can be reasonably reconstructed with highly time-resolved instruments measuring aerosol chemistry
- The OM, AS, and AN are the key components of $PM_{2.5}$ and b_{sp}, but the relative contributions are different between the two sites
- At the NZ site, the SOC is notably higher and is the main source of $PM_{2.5}$ and b_{sp}, compared to the FS site.
- At both sites, elevated levels of $PM_{2.5}$ and b_{sp} are due to enhanced AN formation.
- At both sites, the dominant sources of $PM_{2.5}$ sources are secondary AN (w/ SOC), oil combustion, and traffic (w/ POC), and the source strengths are dependent on air-mass trajectories.
- The 4 IOPs captured clean and pollution events of different source strengths and air-mass trajectories.

ACKNOWLEDGEMENTS

- Taiwan Ministry of Environment (113AA064)
- Taichung Environmental Protection Bureau
- Kaohsiung Environmental Protection Bureau
- Kaohsiung Nanzih Senior High School
- Kaohsiung Fengshan Senior High School

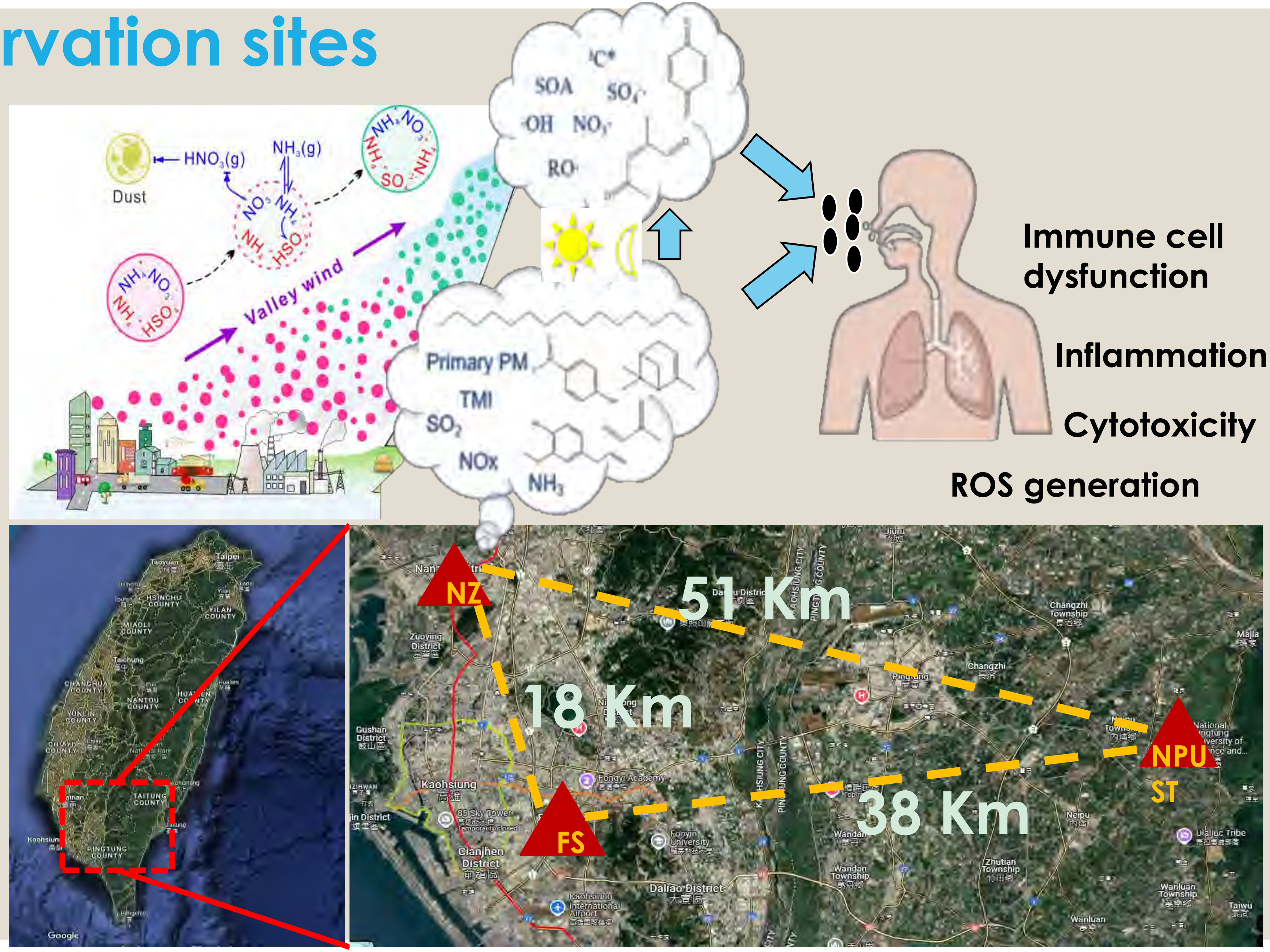
Isotopic Evidence of Nitrate Aerosol formation and Source Dynamics in the Atmosphere of Southern Taiwan

Prateek Sharma, Kuo-Fang Huang, Mao-Chang Liang, and 7-SEAS/KPEx team, Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan

Introduction

- Nitrate aerosols play a critical role in atmospheric chemistry therefore the understanding of formation and sources of nitrate aerosols is crucial.
- They formed through secondary pathways, where nitrogen oxides (NO_x) are oxidized to nitric acid (HNO_3), which then reacts with ammonia (NH_3) to form ammonium nitrate (NH_4NO_3).
- Isotopic analysis ($\delta^{15}N$, $\delta^{18}O$, $\Delta^{17}O$) of nitrate offers insights into its sources and chemical pathways.
- This study, conducted across sites in southern Taiwan, enhances understanding of pollution origins and informs air quality management and policy decisions.
- Nitrate aerosols are formed through the oxidation of nitrogen oxides (NO and NO_2). Different oxidants lead to distinct $\Delta^{17}O$ signatures Ozone (O_3) in the resulting nitrate from Ozone (O_3), Hydroxyl Radical (OH), Hydroperoxyl Radical (HO_2) and Hydrogen Peroxide (H_2O_2).

Observation sites



Process reactions

Day time

$NO + O_3 \rightarrow NO_2 + O_3$ (R1)

$NO_2 + h\nu \text{ (sunlight)} \rightarrow NO + O$ (R2)

$O + O_2 + M \rightarrow O_3 + M$ (R3)

$NO_2 + OH + M \rightarrow HNO_3 + M$ (R4)

Night time

$NO_2 + O_3 \rightarrow NO_3 + O_2$ (R5)

$NO_3 + NO_2 \rightarrow N_2O_5$ (R6)

$N_2O_5 + H_2O \text{ (surface)} \rightarrow 2HNO_3$ (R7)

$N_2O_5 + Cl^- \rightarrow NO_3^-(p) + ClNO_2$ (R8)

Other pathways

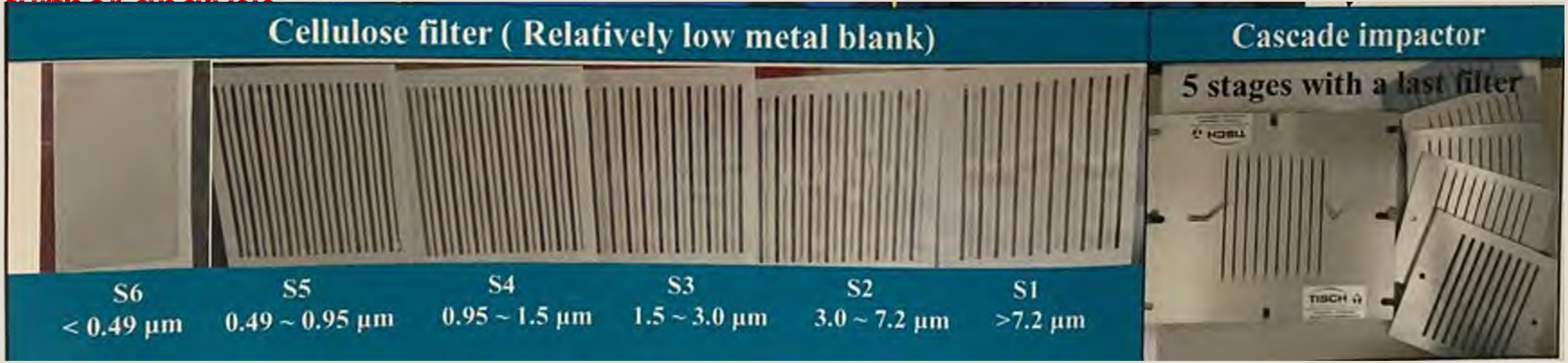
$NO + HO_2(\text{or } RO_2) \rightarrow NO_2 + OH(\text{or } RO)$ (R9)

$NO_2 + BrO + M + H_2O \rightarrow HOBr + HNO_3$ (R10)

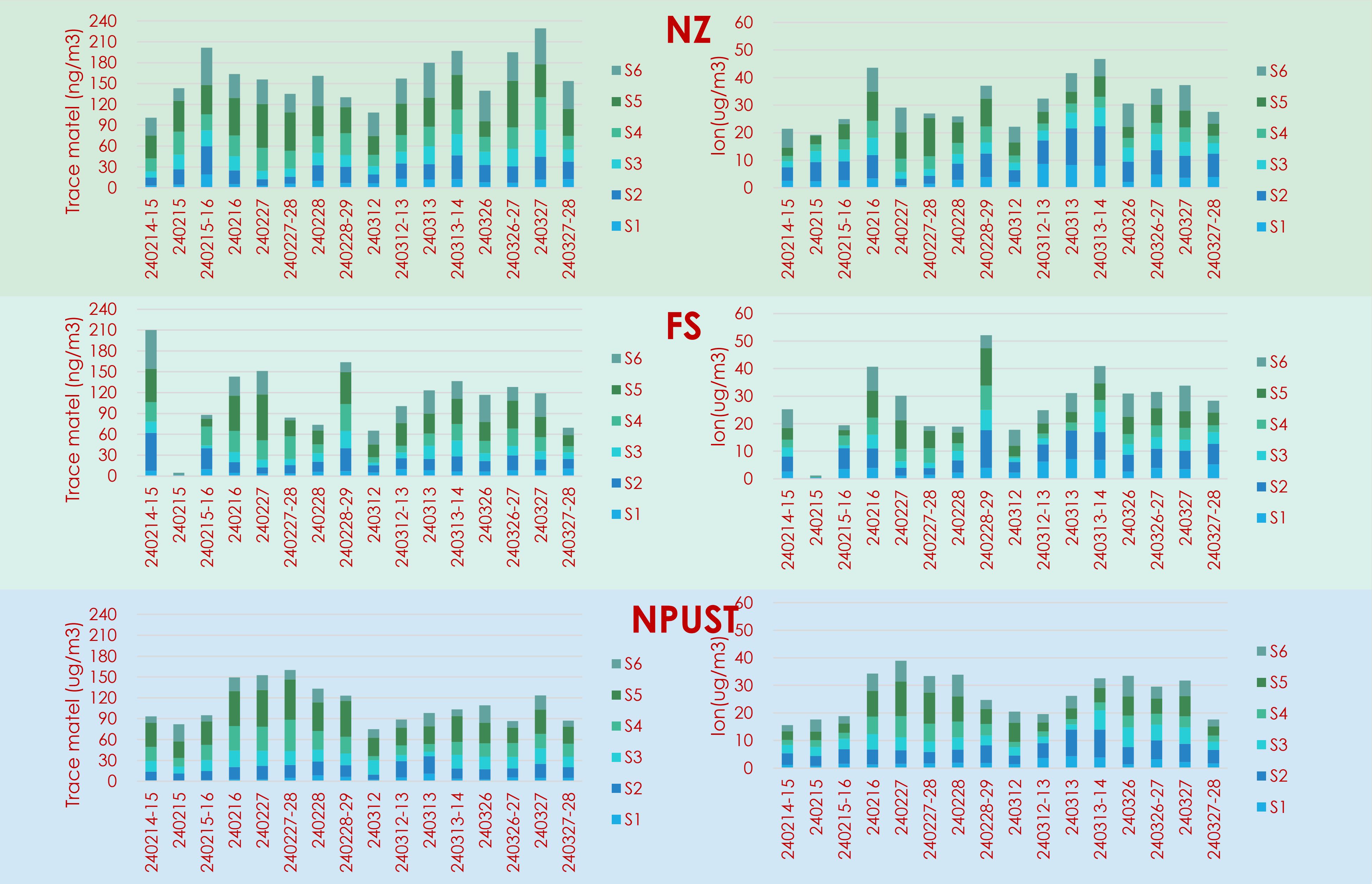
Sampling

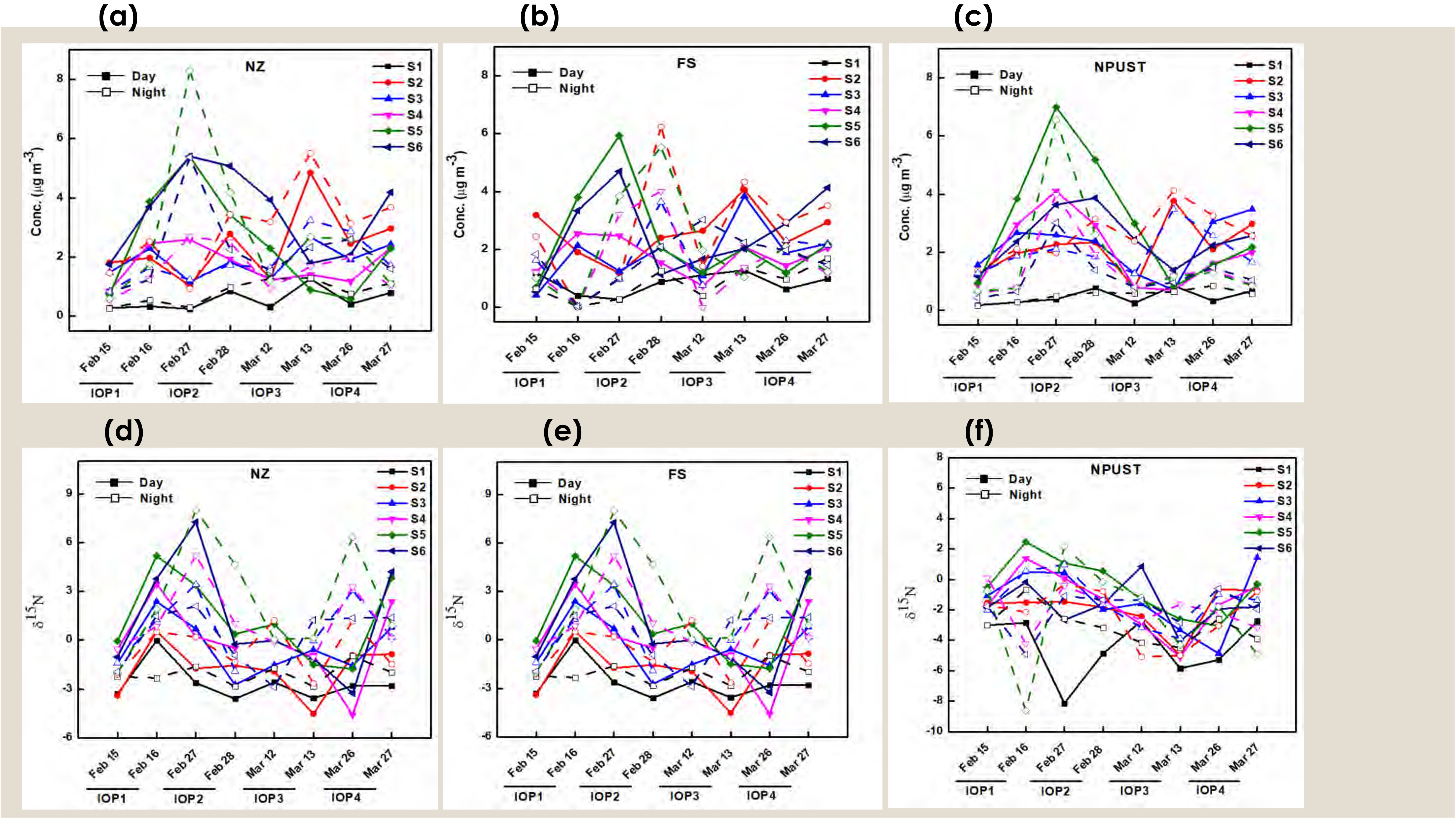
Size-resolved aerosol samples were collected on polycarbonate membranes for 24 h diurnally at three different locations on four different IOPs using high volume samplers with a 5-stage impactor at a flow rate of 40 CFM (~1 m^3/min). After collection, each filter is transferred into a plastic bag and stored at -20 °C for further analysis.

Tisch HiVol TSP



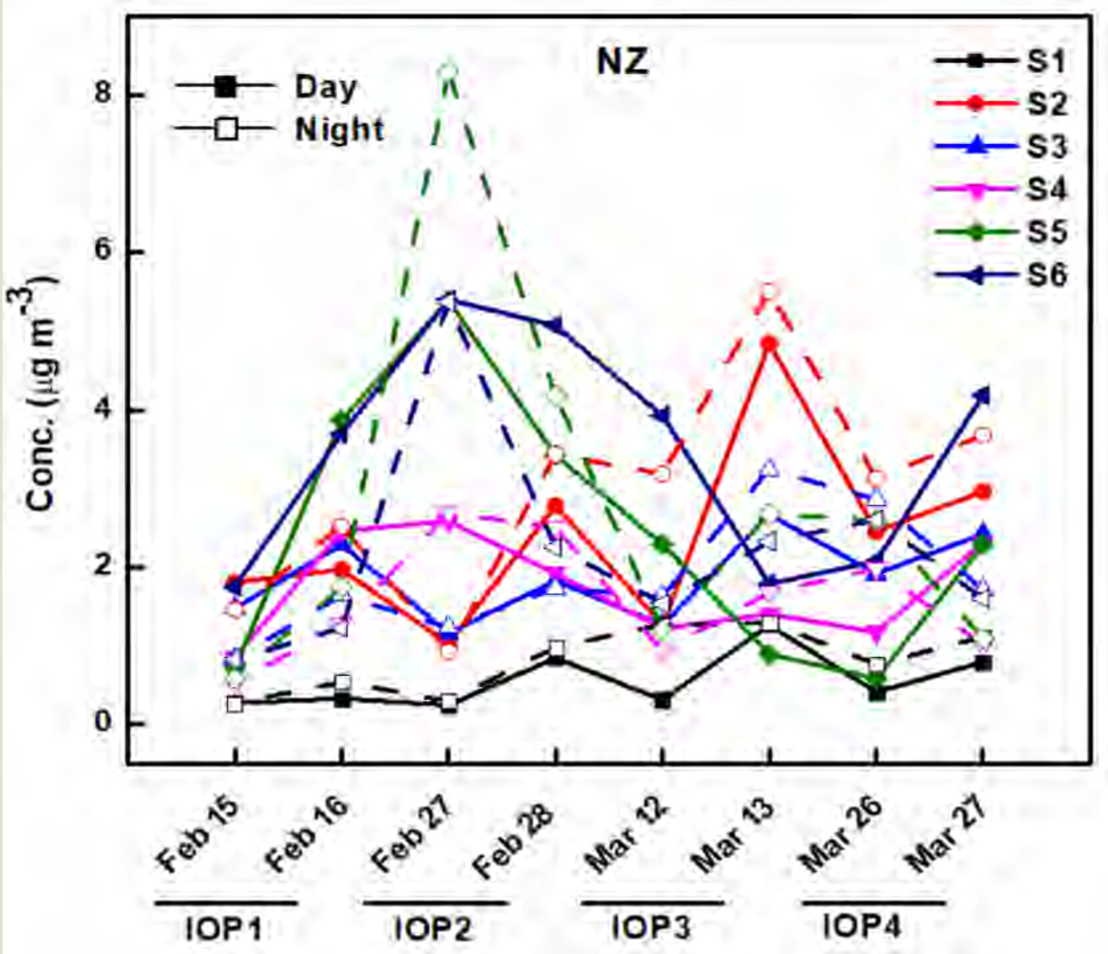
Total metal/ion concentration

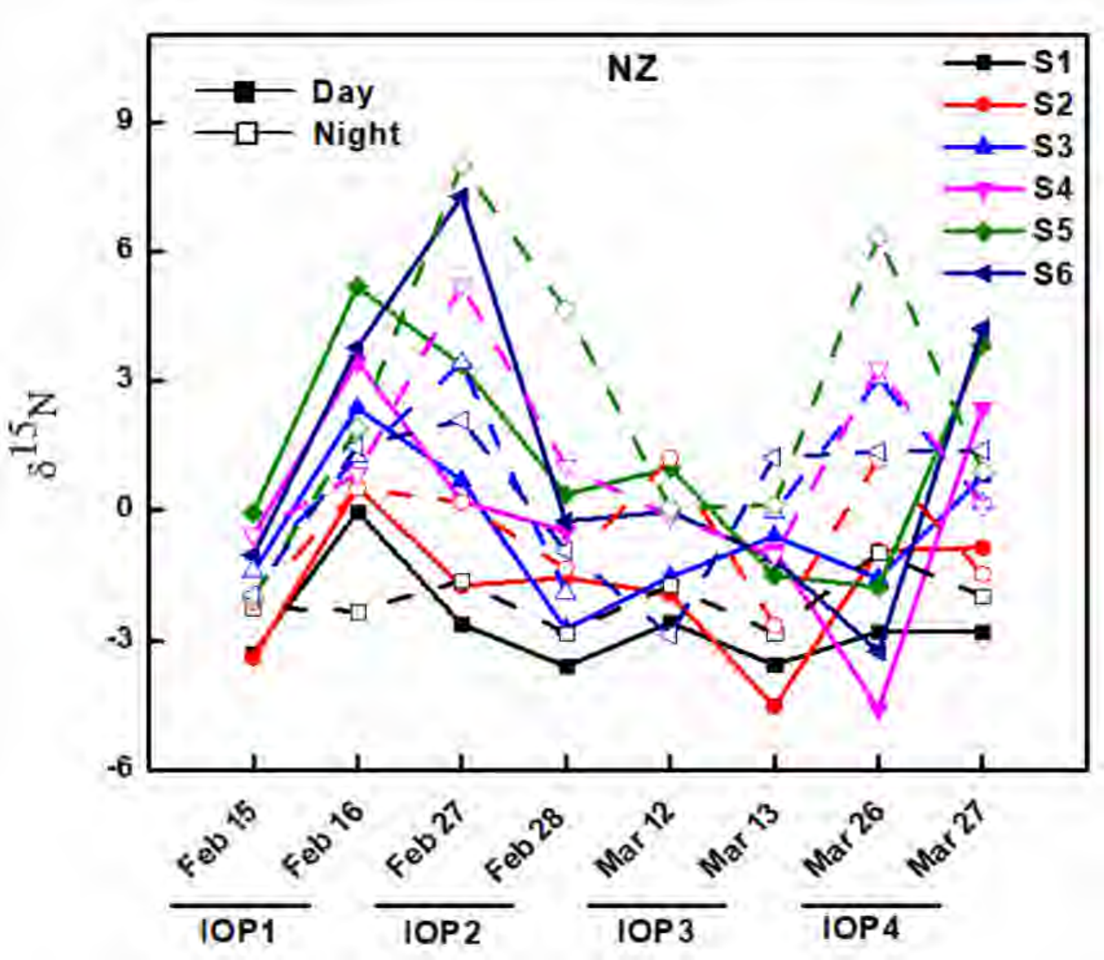




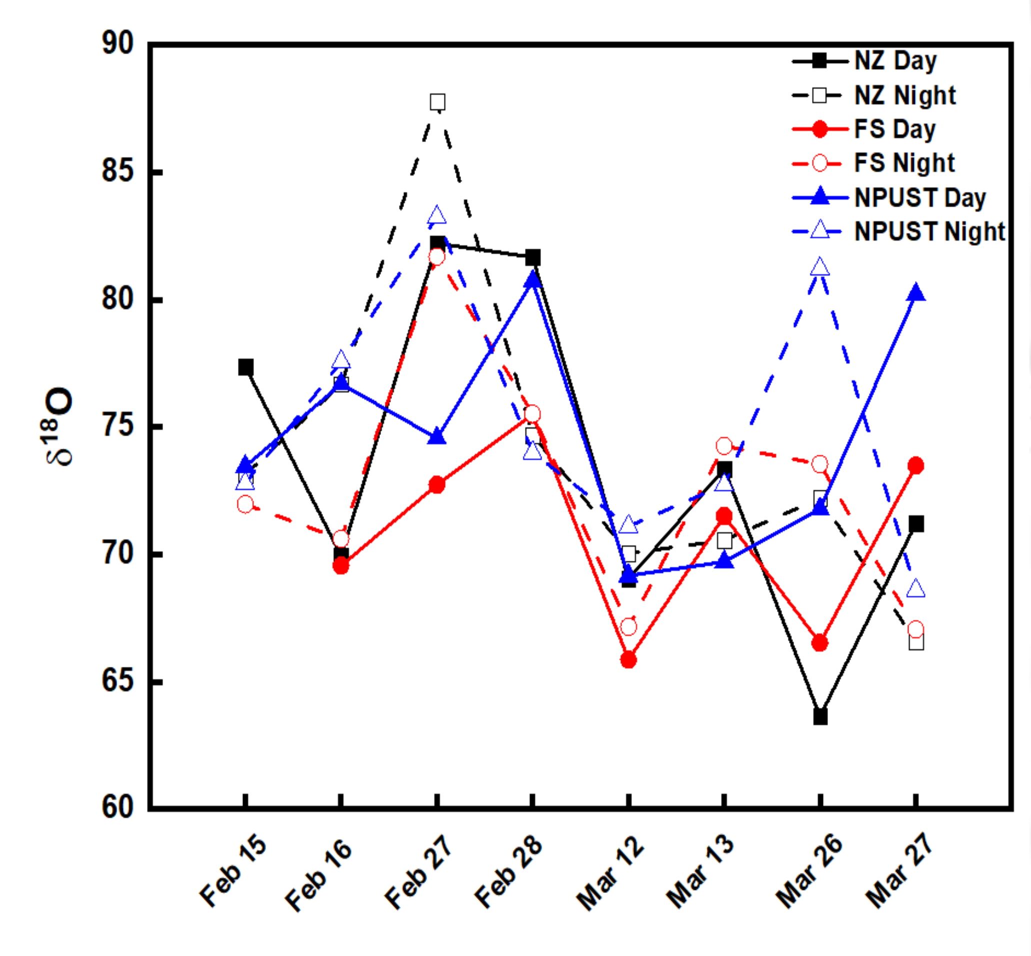
(a)
(b)
(c)
(d)
(e)
(f)
NZ
FS
NPUST
Day
Night
S1
S2
S3
S4
S5
S6
Conc. (μg m-3)
δ15N
Feb 15
Feb 16
Feb 27
Feb 28
Mar 12
Mar 13
Mar 26
Mar 27
IOP1
IOP2
IOP3
IOP4

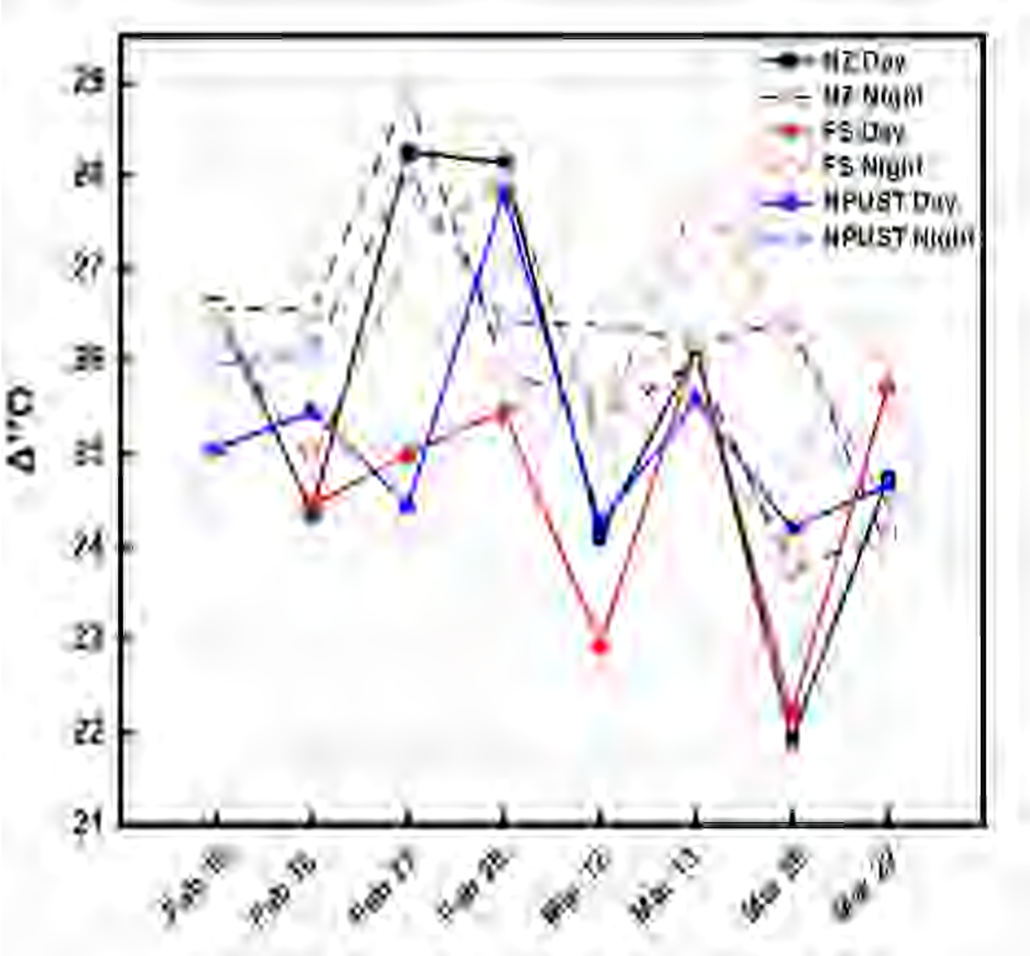
Time series for nitrate conc. and $\delta^{15}N$



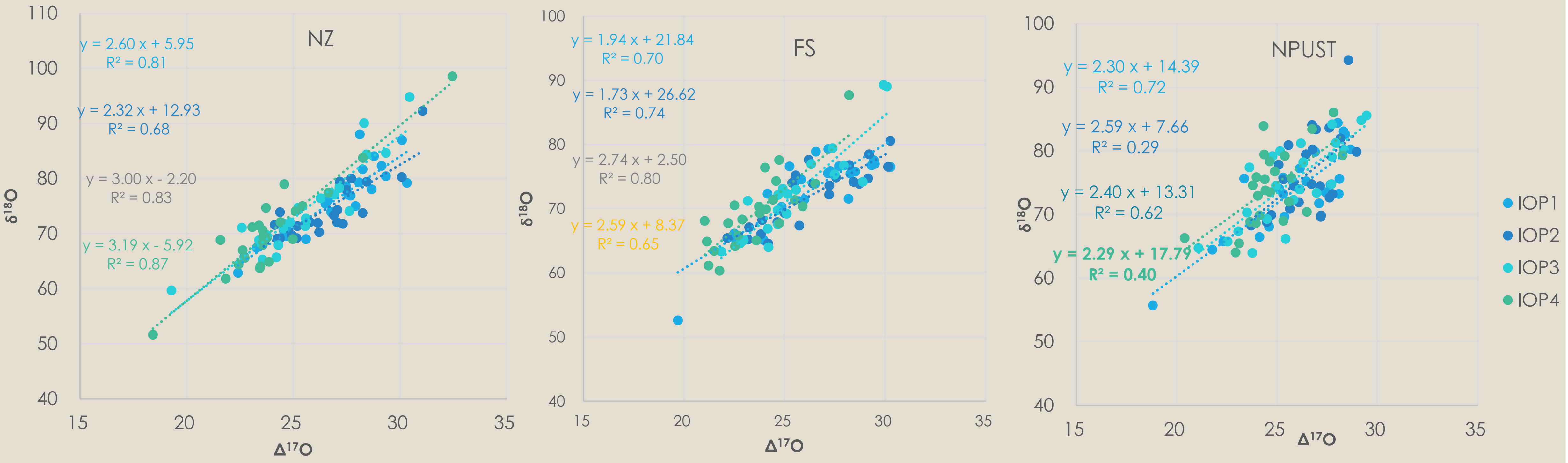


Time series for average $\delta^{18}O$ and $\Delta^{17}O$ values





Correlation of δ¹⁸O and Δ¹⁷O



Model

- A Bayesian model in the Stable Isotope Analysis in R, SIAR was employed for determining the relative contributions of the three different formation pathways to pNO_3^-.

- The set of N mixture measurements on oxygen isotopes ($\Delta^{17}O$) with j formation pathways are defined as

$$X_i = \sum_{1}^{j} f_j \times S_j$$

where X_i is the $\Delta^{17}O$ values of the mixture i (i = 1, 2, ..., N) and f_j is the proportion of each pathway j identified by the SIAR model.

- The summation of all the f j values is equal to 1. S_j represents the $\Delta^{17}O$ value of each pathway j and is distributed

A total of 2000 feasible solutions of f_j was generated through the Monto Carlo simulation performed with the SIAR model.

Formation pathways

Here, we used $\Delta^{17}O$-NO3⁻ to quantitatively estimate the relative contributions from following pathways to particulate nitrate formation at the different sites by combining with the SIAR model

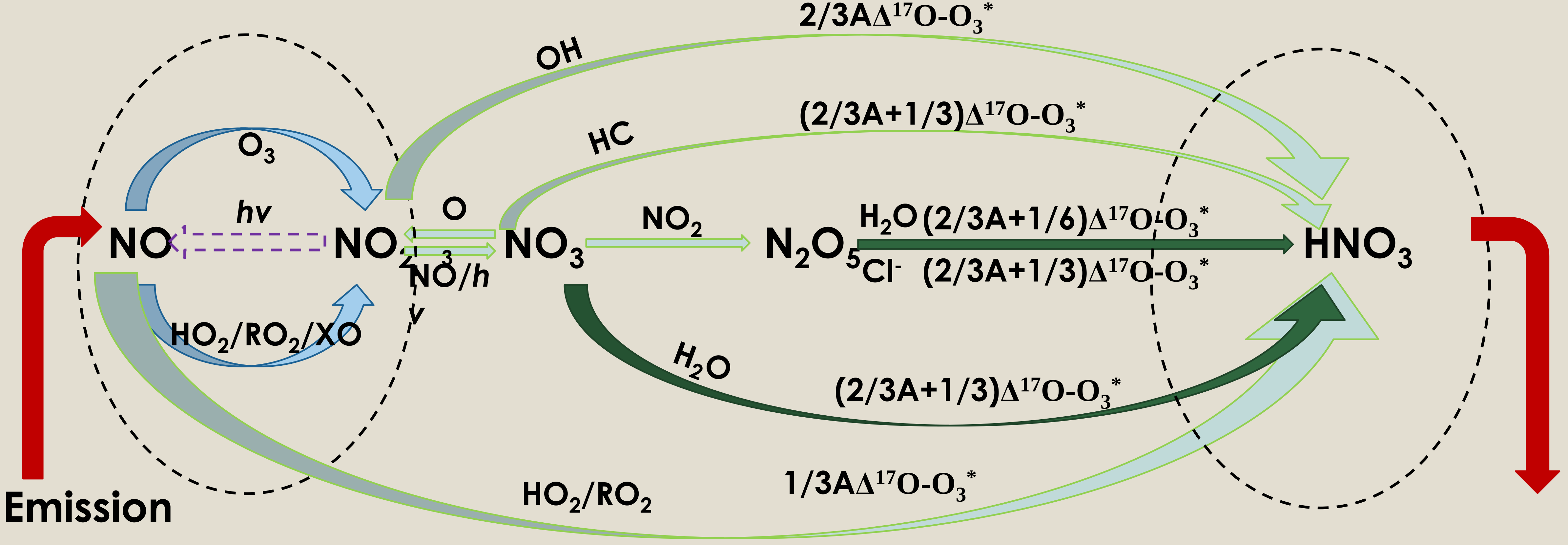
- Pathway 1, P_1: ($OH/H_2O + NO_2$, f_{P1})
- Pathway 2, P_2: (NO_3 + HC and $N_2O_5 + Cl^-$, f_{P2})
- Pathway 3, P_3:($N_2O_5 + H_2O$, f_{P3})

Therefore, the observed $\Delta^{17}O$ isotope can be expressed as:

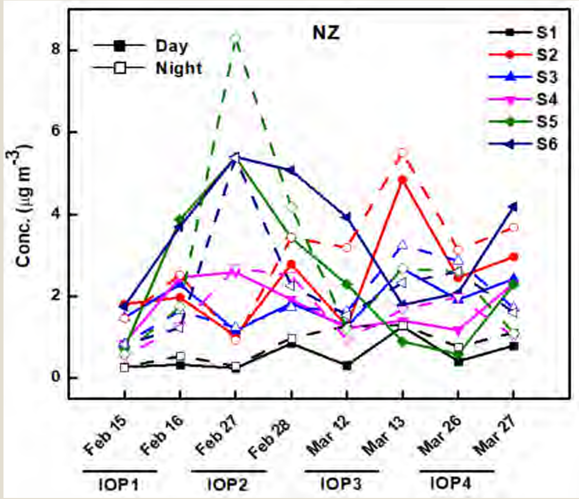
$$[\Delta^{17}O\text{-}NO_3^-] = [\Delta^{17}O\text{-}NO_3^-]_{P1} * f_{P1} + [\Delta^{17}O\text{-}NO_3^-]_{P2} * f_{P2} + [\Delta^{17}O\text{-}NO_3^-]_{P3} * f_{P3}$$

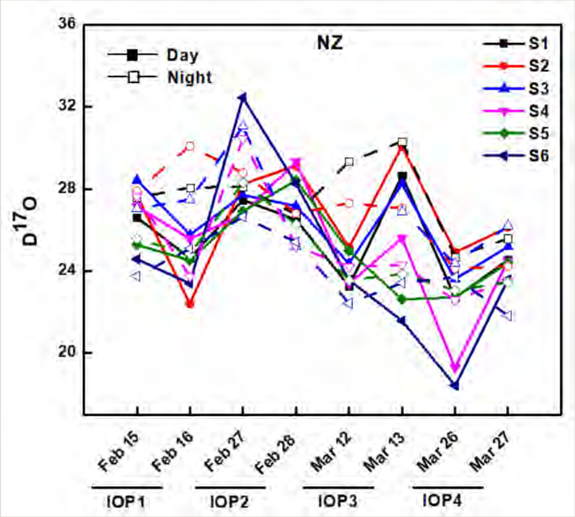
Where, $f_{P1} + f_{P2} + f_{P3} = 1$

Formation pathways of HNO_3 in the atmosphere



MixSIAR model for tracing pathways





Summary

- This study provides a comprehensive analysis of nitrate aerosols in Southern Taiwan, emphasizing the isotopic signatures to reveal their sources and formation mechanisms.
- Thus O_3 is the only source of $\Delta^{17}O$ in NO_3^- and the variation helps to determine the nitrate formation pathways.
- The higher nitrate concentrated IOP dominated by the nocturnal chemistry (N_2O_5+H_2O/Cl^-) became the major formation mechanism.

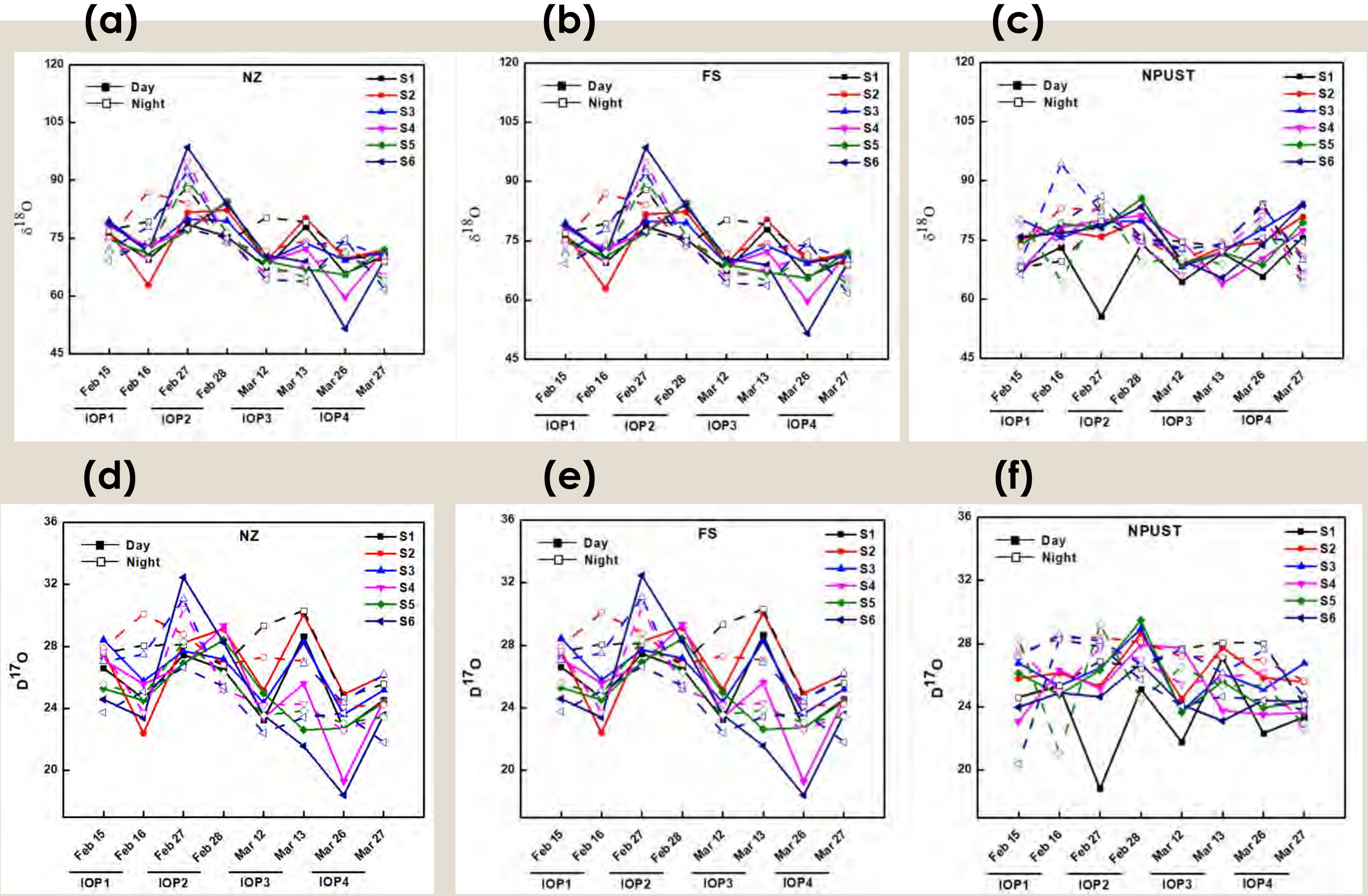
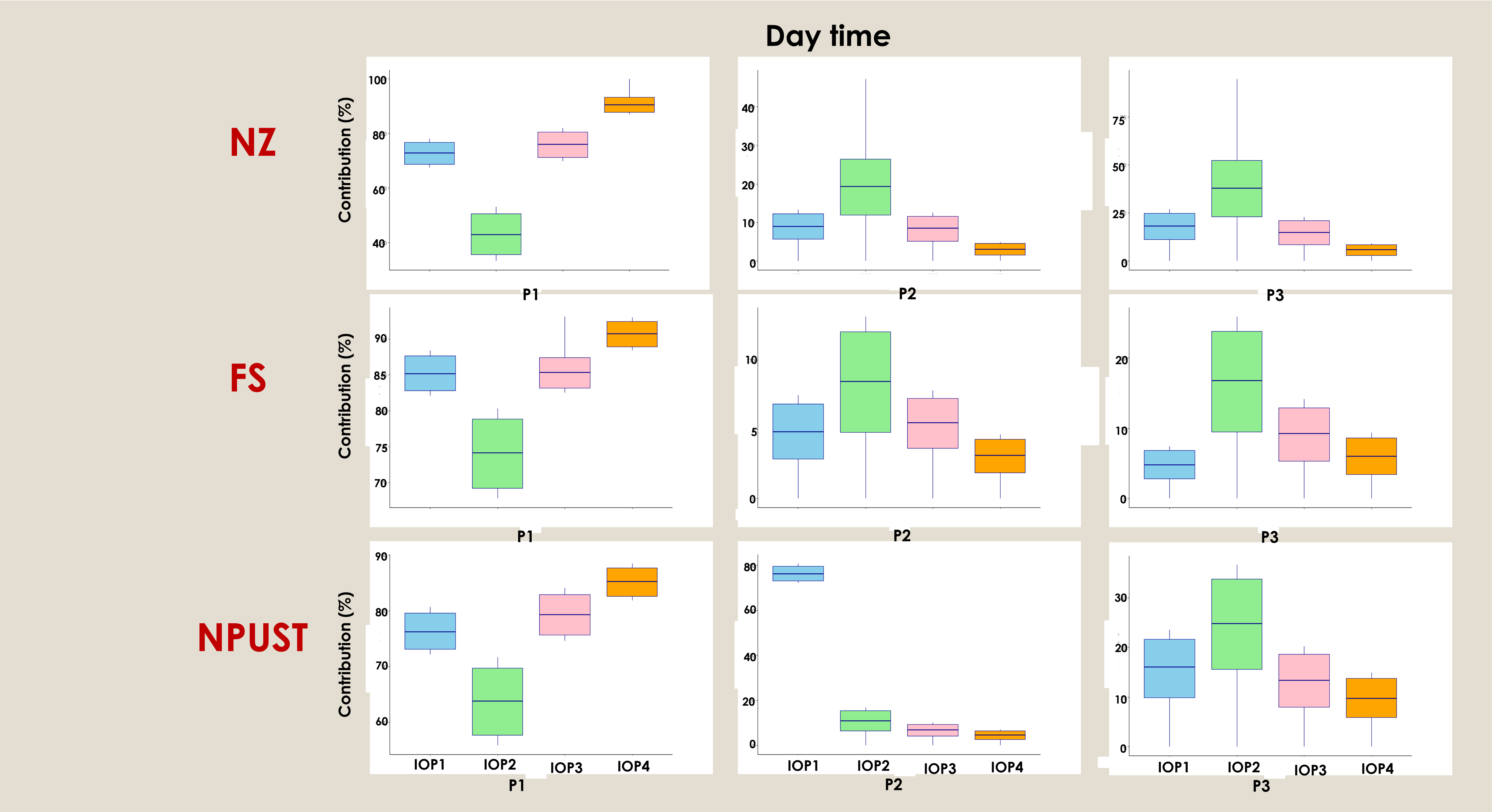


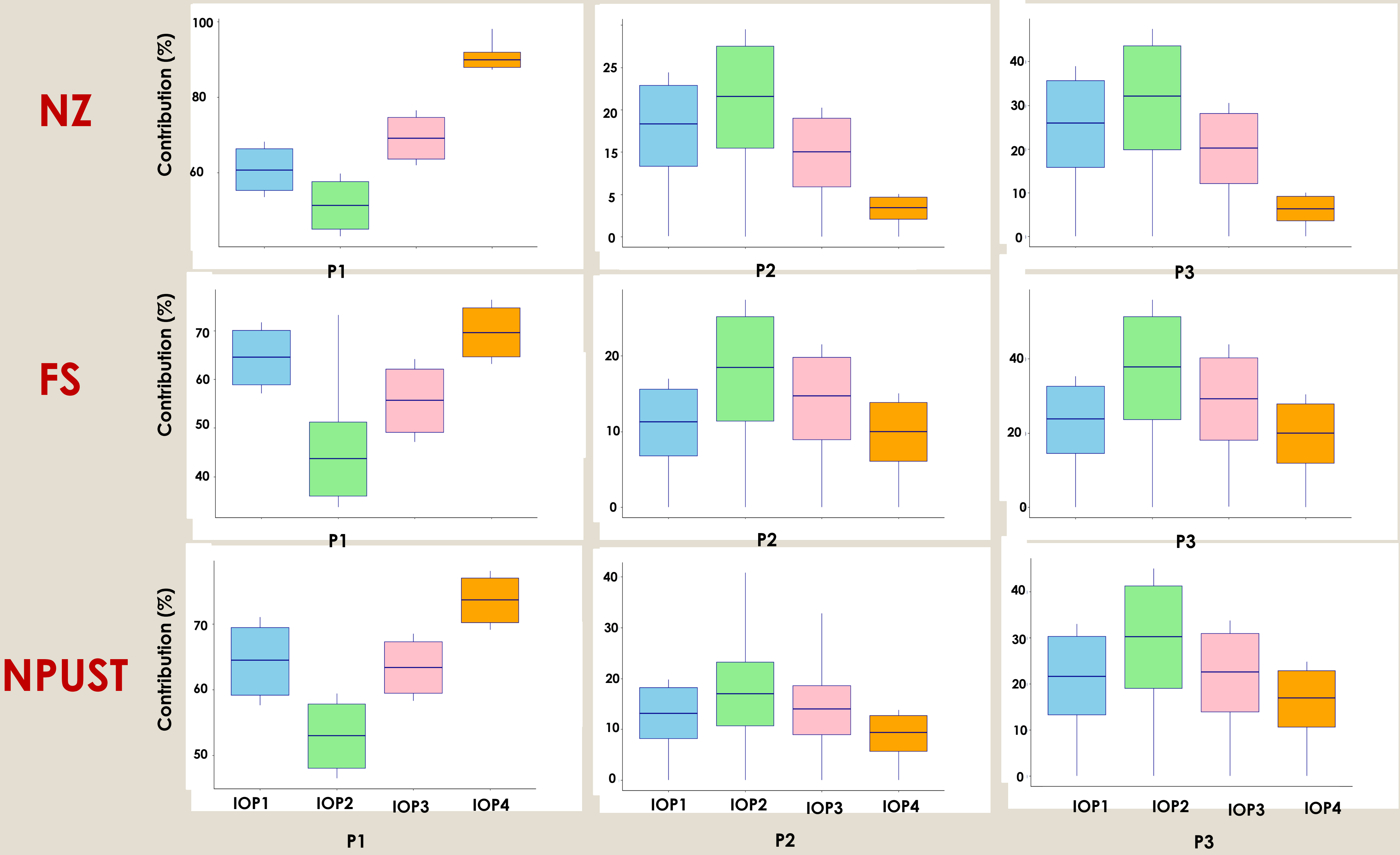
Fig. 6 Variation of (a–c) $\delta^{18}O$, and the correlation plot between $\delta^{18}O$ and $\Delta^{17}O$ values across different IOPs for NZ, FS, and NPUST sampling sites, respectively.



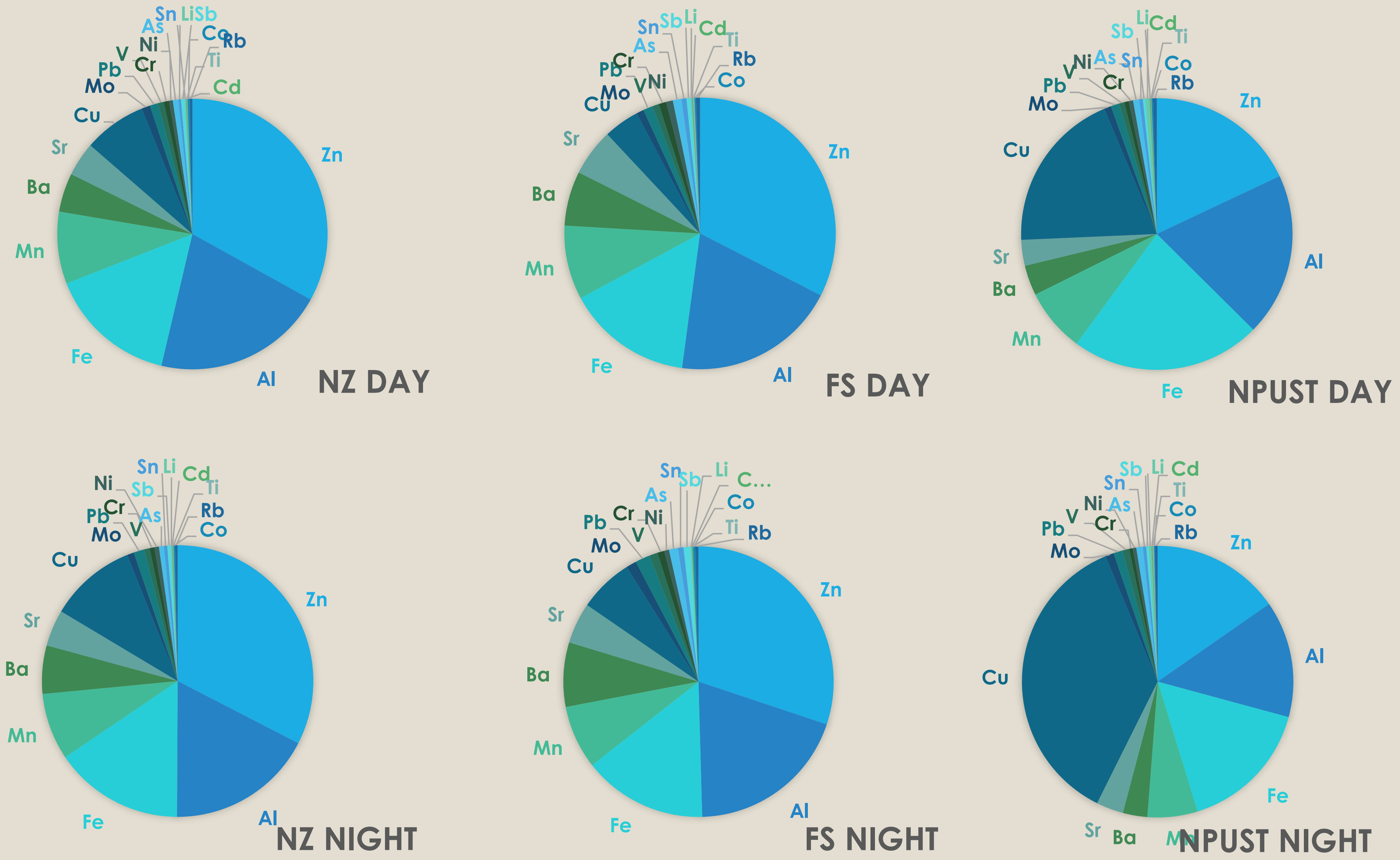
Day time
NZ
FS
NPUST
Contribution (%)
P1
P2
P3
IOP1
IOP2
IOP3
IOP4

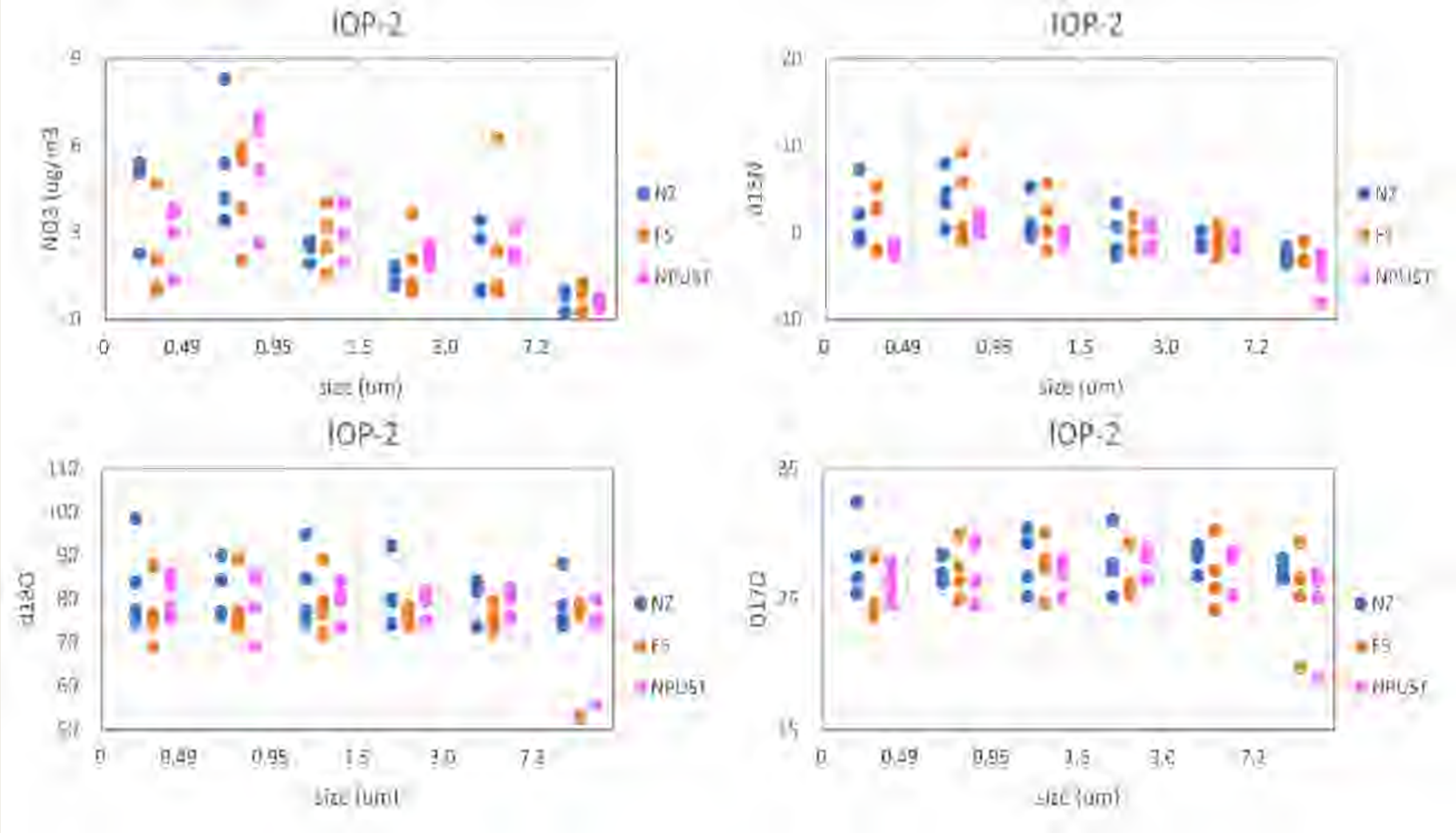
MixSIAR

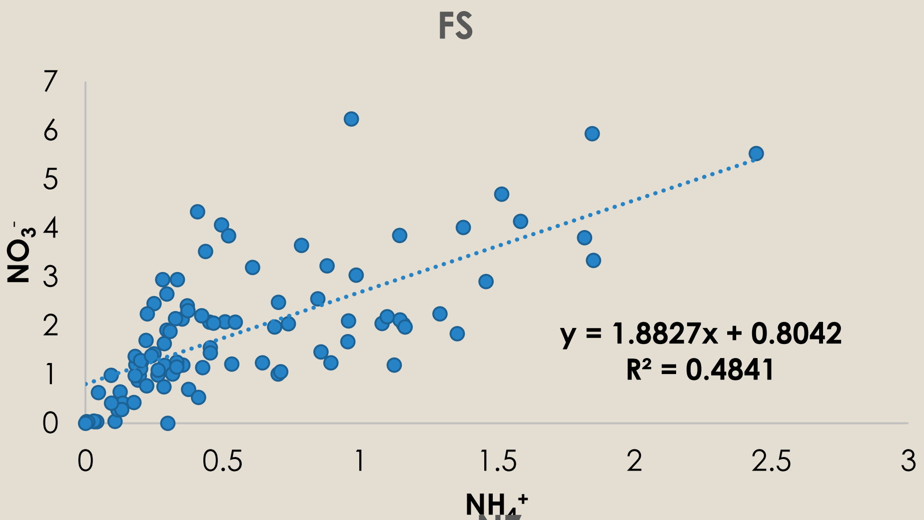
Night time

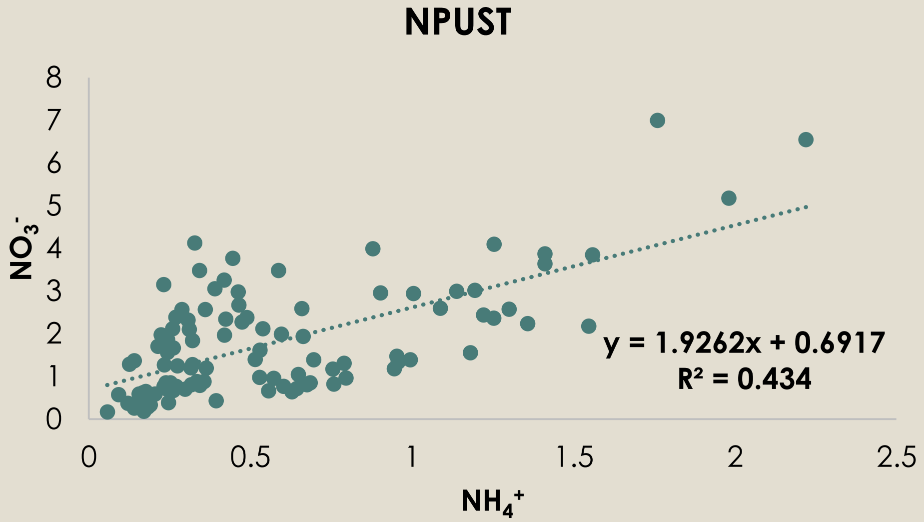


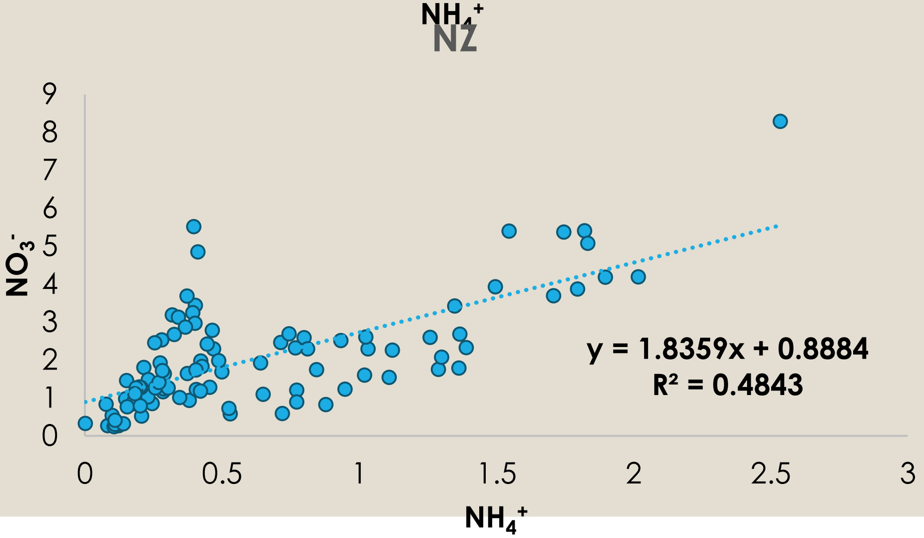
Trace metal ion



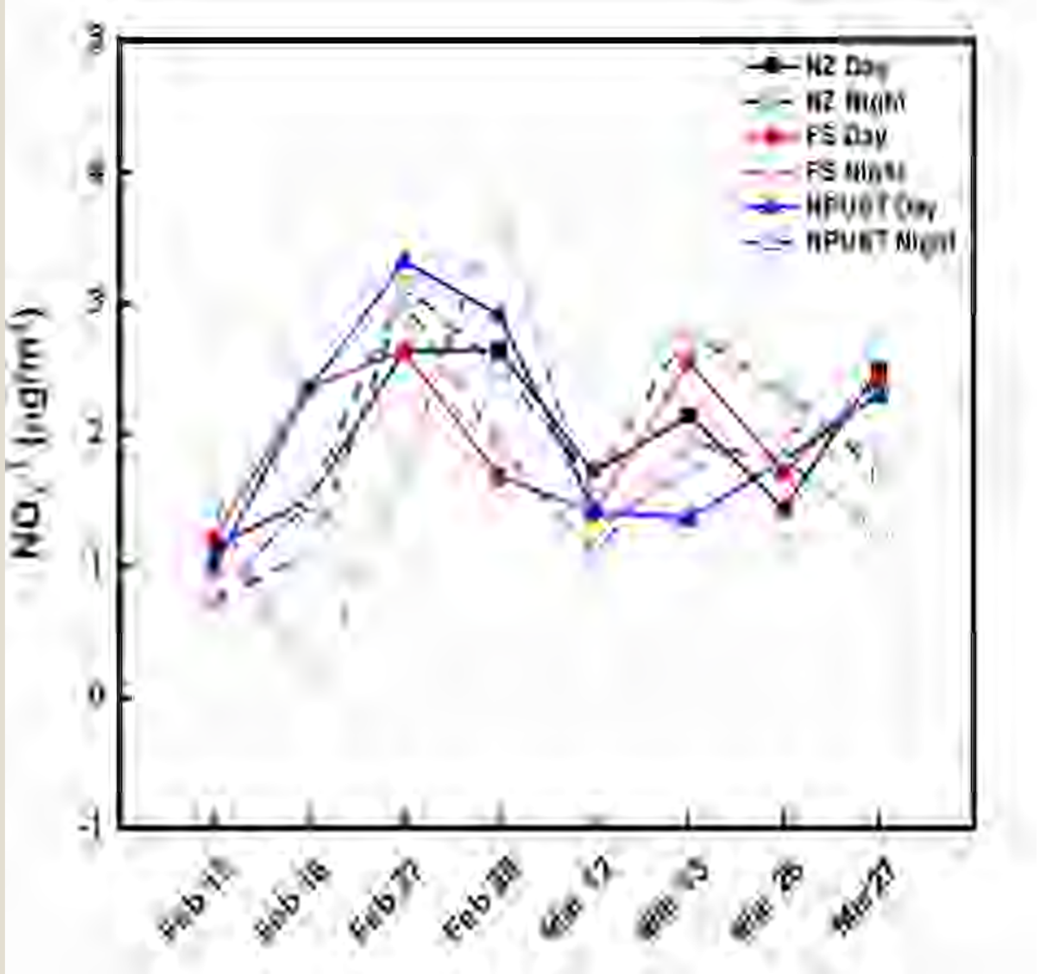

IOP-2
NO3 (ug/m3)
d15N
d18O
D17O
0
0.49
0.95
1.5
3.0
7.2
size (um)
NZ
FS
NPUST

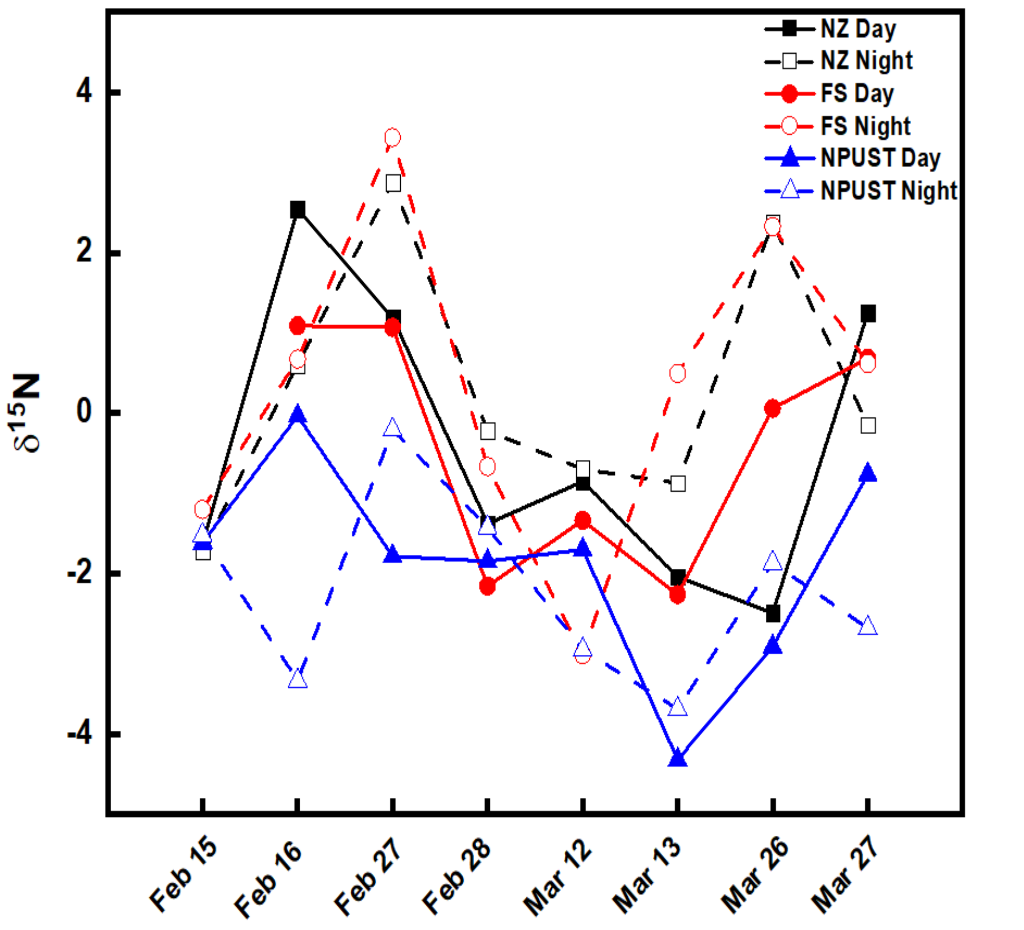

FS
y = 1.8827x + 0.8042
R² = 0.4841
NO3-
NH4+


NPUST
y = 1.9262x + 0.6917
R² = 0.434
NO3-
NH4+

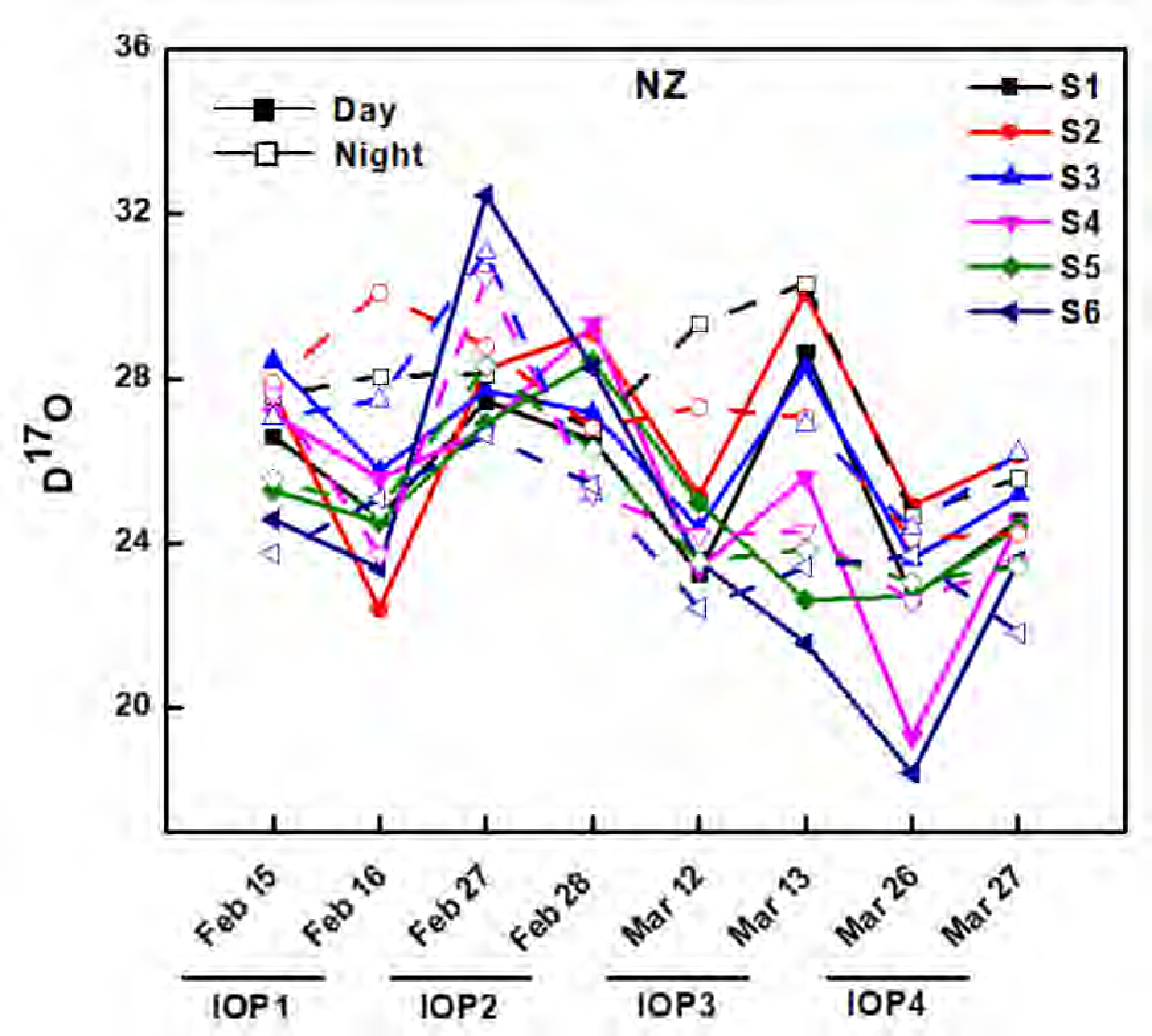

NZ
y = 1.8359x + 0.8884
R² = 0.4843
NO3-
NH4+

Time series for average NO_3^{-1} and $\delta^{15}N$ values





Time series for $\Delta^{17}O$ in nitrate



Atmospheric PAHs, Source Attributed Profile and Oxidative Potential in $PM_{2.5}$ during Daytime and Nighttime in Kao-Ping Experiment (KPEx)

NATIONAL
YANG MING CHIAO TUNG
UNIVERSITY

Kai Yu Hsu[1], Shih Yu Pan[1], Yu-Chieh Ting[2], Charles C.-K. Chou[3],
Ta-Chih Hsiao[2], Neng-Huei Lin[4] and Kai Hsien Chi[1*]
[1]Institute of Environmental and Occupational Health Sciences,
National Yang Ming Chiao Tung University, Taipei 112, Taiwan.
[2]Graduate Institute of Environmental Engineering, National Taiwan University, Taipei 106, Taiwan.
[3]Research Center for Environmental Changes, Academia Sinica, Taipei 115, Taiwan.
[4]Department of Atmospheric Sciences, National Central University, Taoyuan, 32001, Taiwan.

Air Pollutants –
Fine Particulate Matter

Sources

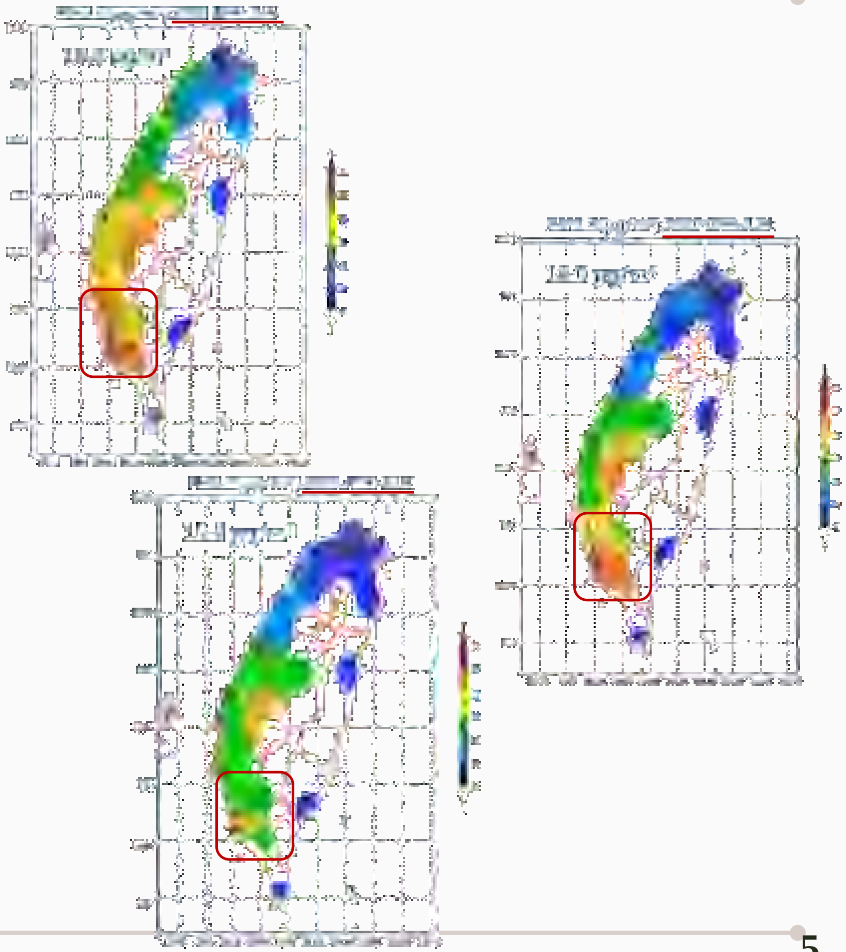
- Traffic (mobile sources)
- Combustion processes
- Industrial activities (fixed sources)

(Fang et al., 2016; Janssen et al., 2015; Zhu et al., 2015)

Health effect

- Cardiovascular diseases
- Respiratory problems
- Adverse neurodevelopmental effects

(Janssen et al., 2014; Bates et al., 2015)



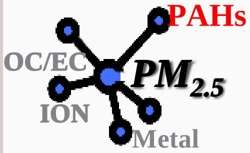
Air Pollutants – PAHs

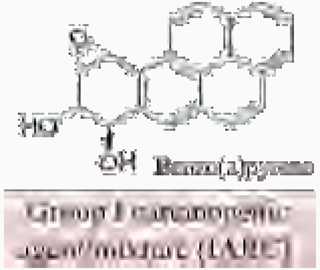
- Polycyclic aromatic hydrocarbons (PAHs) from **incomplete combustions** are widespread in the environment.

(Bostr€om et al., 2002; IARC,1987; WHO/IPCS, 1998)

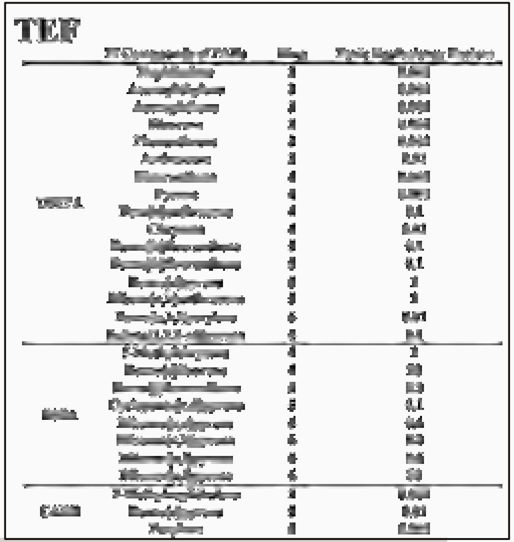
- In order to obtain an **accurate assessment of the potential risk** of exposure to a complex mixture of PAHs, several approaches were developed using **toxic equivalency factors (TEF)** based on **BaP**.

(Teixeira et al., 2017; Jung et al., 2010; Nisbet and LaGoy., 1992; Durant et al., 1999)





(Yang et al.,2018)



Health effect

- Oxidative stress
- Heart disease
- Systemic inflammation
- kidney and liver damage,
- Children's cognitive development

(Mallah et al.,2022)

-KPEx Sampling site-

Nanzi

-Industrial site-

Fengshan

-Traffic site-

Shibata HV-1000R

- Collection: **$PM_{2.5}$**
- Sampling time:
  - **Daytime** (9hrs) & **Nighttime** (15hrs)
  - 24hrs
- Flow rate: **1000** (L/min)

- **Sampling period**

***IOP: Intensive Observation Period**

- Feb.2024

2/2、2/8、2/13、2/14、2/15 (IOP1)、2/16、2/17、2/18、2/19、2/20、2/25、2/26、2/27、2/28 (IOP2)、2/29

- Mar.2024

3/4、3/9、3/12、3/13 (IOP3)、3/20、3/22、3/23、3/24、3/25、3/26、3/27 (IOP4)

Oxidative potential (OP)

oxidative potential (OP)
dithiothreitol (DTT) assay

OP:

- The capacity of PM to elicit damaging oxidative reactions.
- Alternate metric of the PM toxicological response.

(Ayres et al., 2008; Li et al., 2008; Saffari et al., 2014; Hedayat et al., 2014; Janssen et al., 2015; Crobeddu et al., 2017; Calas et al., 2018)

DTT:

- The DTT assay is based on the catalytic ability of active redox species associated with PM to transfer electrons from DTT to oxygen.
- DTT is used as a surrogate for biological reducing agents (e.g., NADPH).
- The DTT consumption is proportional to the OP of PM.
- Various chemical components have been demonstrated to be DTT-active.

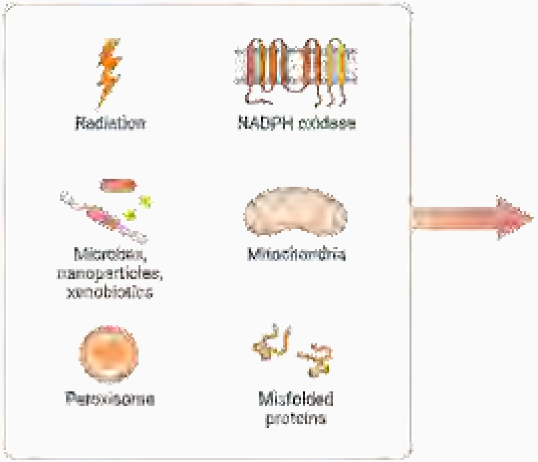
(Lin and Yu, 2011; Verma et al., 2014)

Oxidative potential (OP)

{ **reactive oxygen species (ROS)** }

The linkage between PM exposure and adverse health effects has not been fully established yet, there is increasing consensus on a mechanism that involves the production of oxidative stress through the generation of excessive reactive oxygen species (ROS) and inadequate antioxidant defenses.

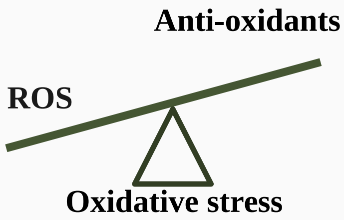
(Li et al., 2008; Akhtar et al., 2010; Bates et al., 2015; Quintana-Belmares et al., 2015; Verma et al., 2015; Antiñolo et al., 2015)



Reactive oxygen species (ROS):

- superoxide anion (O_2^-)
- hydrogen peroxide (H_2O_2)
- hydroperoxyl (HO_2)
- hydroxyl (OH) radicals

(Shiraiwa et al., 2012)



Oxidative potential (OP) experiment - DTT assay

Sample

Sonication

+ 0.1 M **K buffer** (1mL, pH =7.4)
+ 0.5 mM **DTT** (0.1mL)

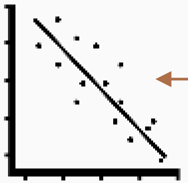
37ºC

Thermo mixer

(2, 8, 15, 22 ,28 mins)

+ **DTNB**
(0.5 mL, 0.2 mM)

UV-Vis
(Evolution 200)



Regression line

- **OP activity**

$$\Delta DTT = -\sigma Abs \times \frac{N_{DTT}}{Abs_0}$$

Volume-normalized OP activity

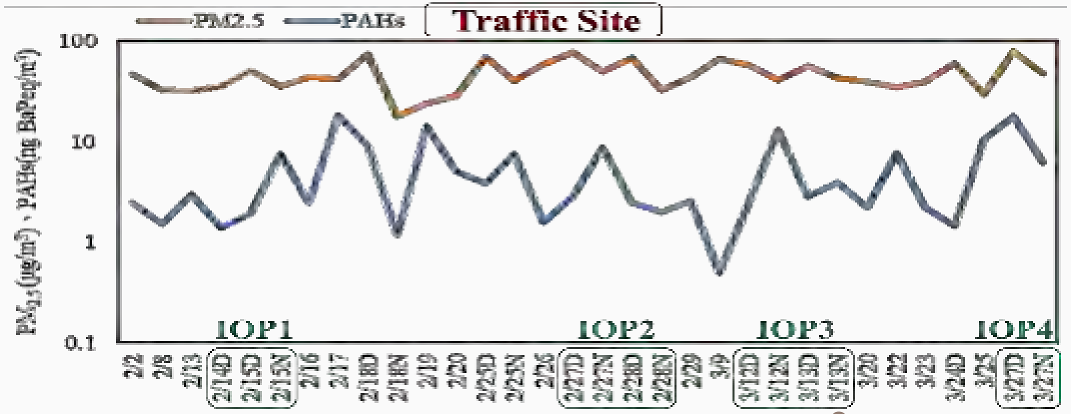
$$OP_V = \frac{\Delta DTT}{V_{air}}$$ (Unit: nmol/min/m^3)

Mass-normalized OP activity

$$OP_M = \frac{\Delta DTT}{M_{particle}}$$ (Unit: pmol/min/μg)

(Hsiao et al., 2021)

Time series and concentration of $PM_{2.5}$ and PAHs in different sampling sites



Industrial site

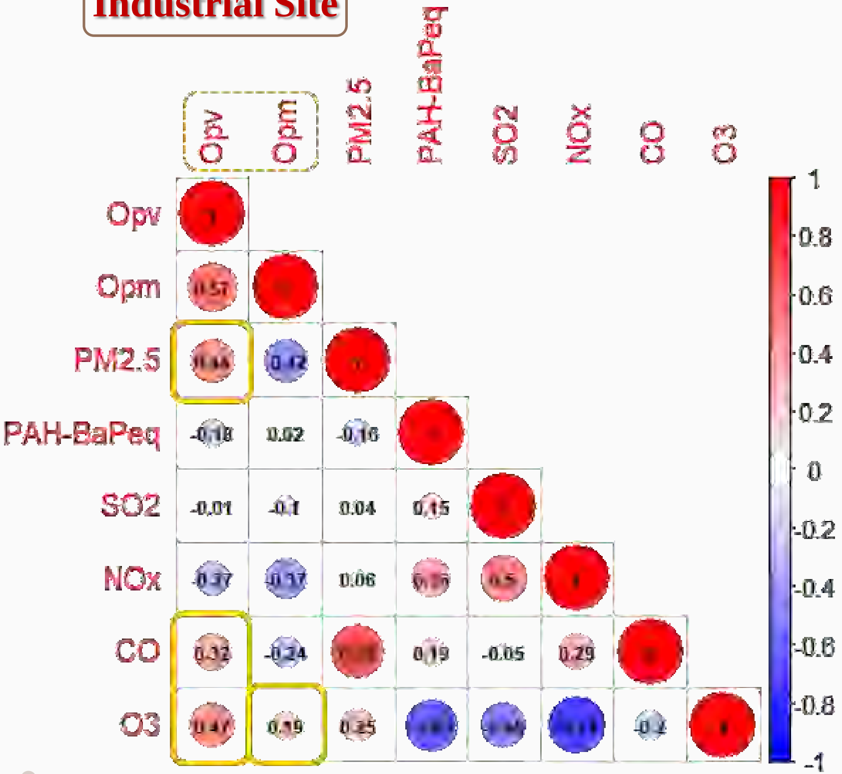
Con.	
$PM_{2.5}$ (μg/m^3)	PAHs (ng BaPeq/m^3)
24.7~85.5 **(44.8±14.8)**	0.373~48.3 **(6.86±9.87)**

Traffic site

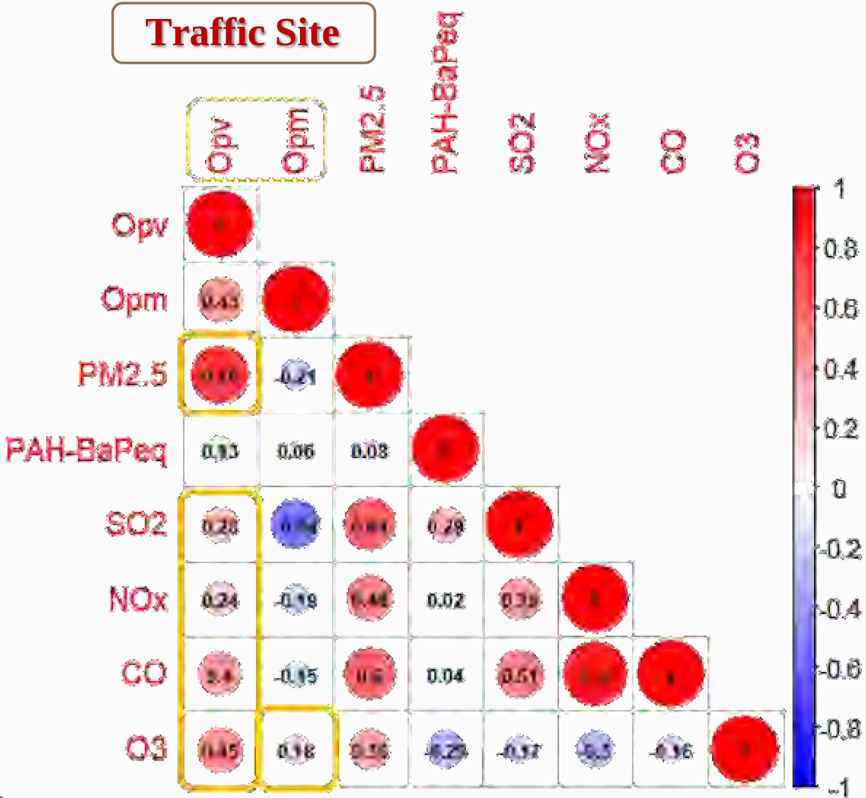
Con.	
$PM_{2.5}$ (μg/m^3)	PAHs (ng BaPeq/m^3)
17.7~79.1 **(46.4±15.8)**	0.487~18.1 **(5.31±4.85)**

The correlation between OP and ambient air pollutants in different sampling sites

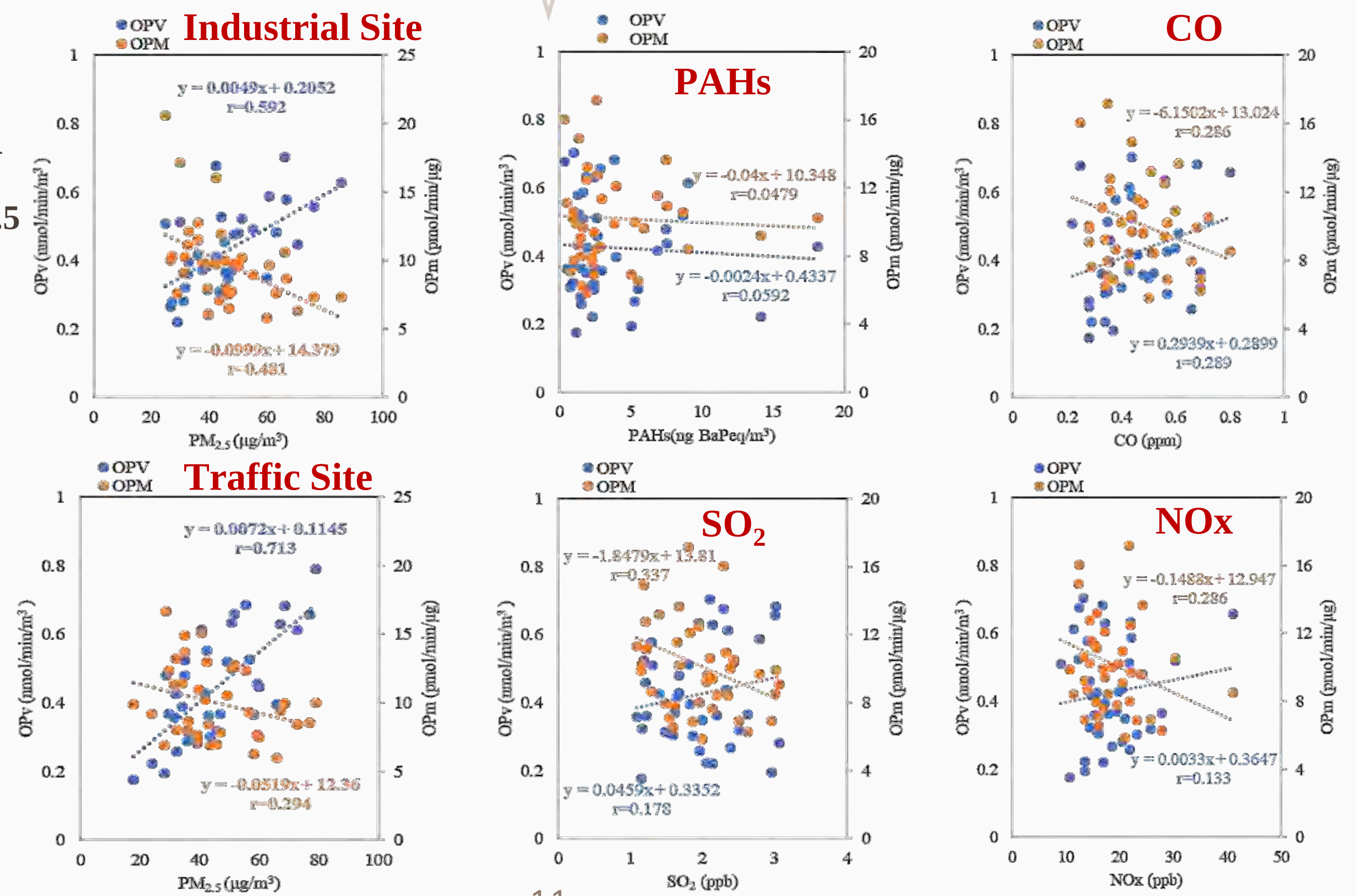
Industrial Site



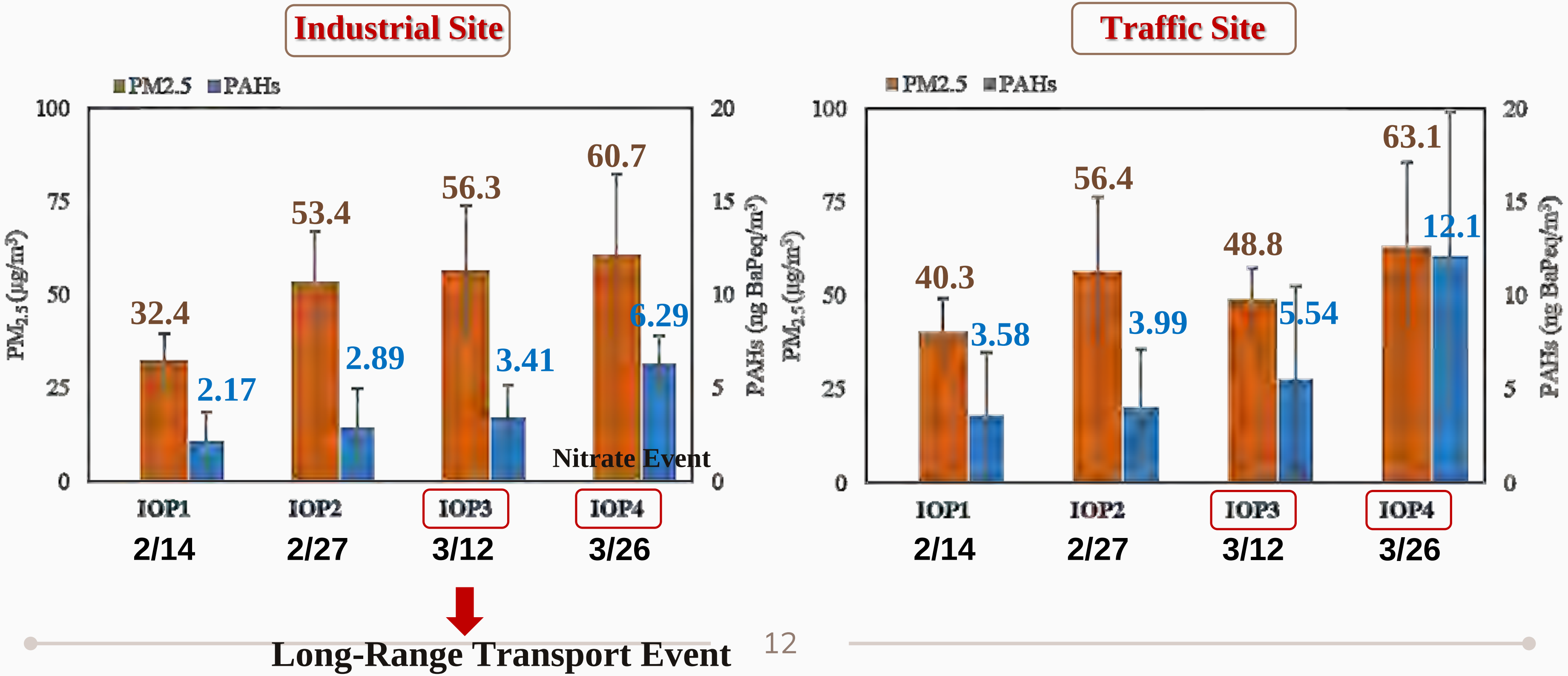
Traffic Site



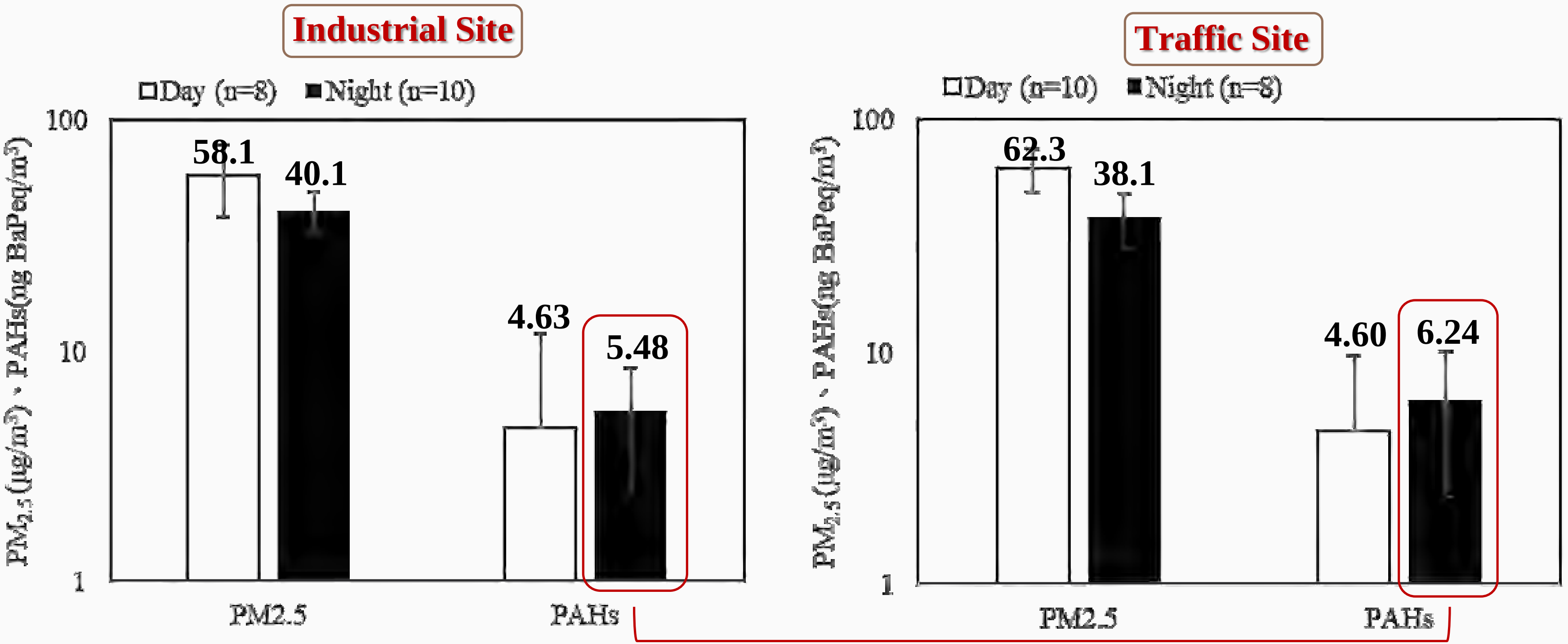
The correlation of OP and $PM_{2.5}$ in different sampling sites



The concentration of $PM_{2.5}$ and PAHs during IOPs



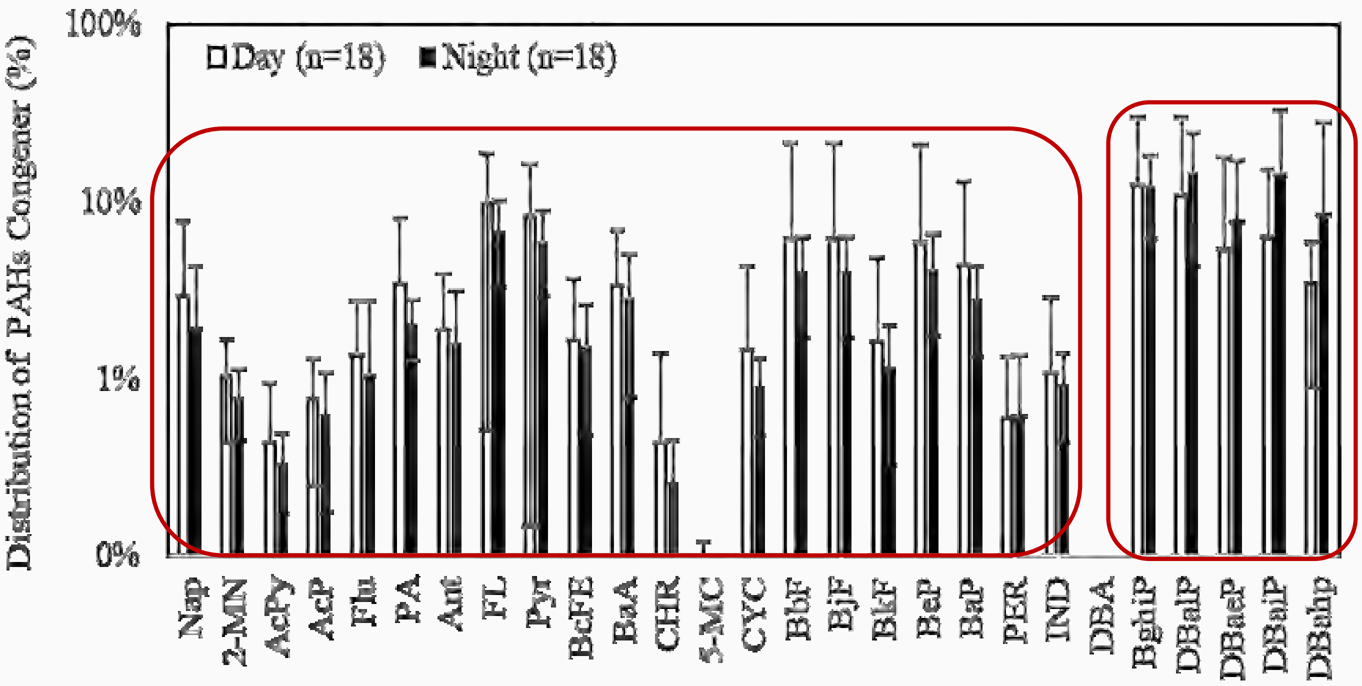
The concentration of $PM_{2.5}$ and PAHs during daytime and nighttime



Lower temperature & Absence of sunlight

→ Enhance atmospheric persistence

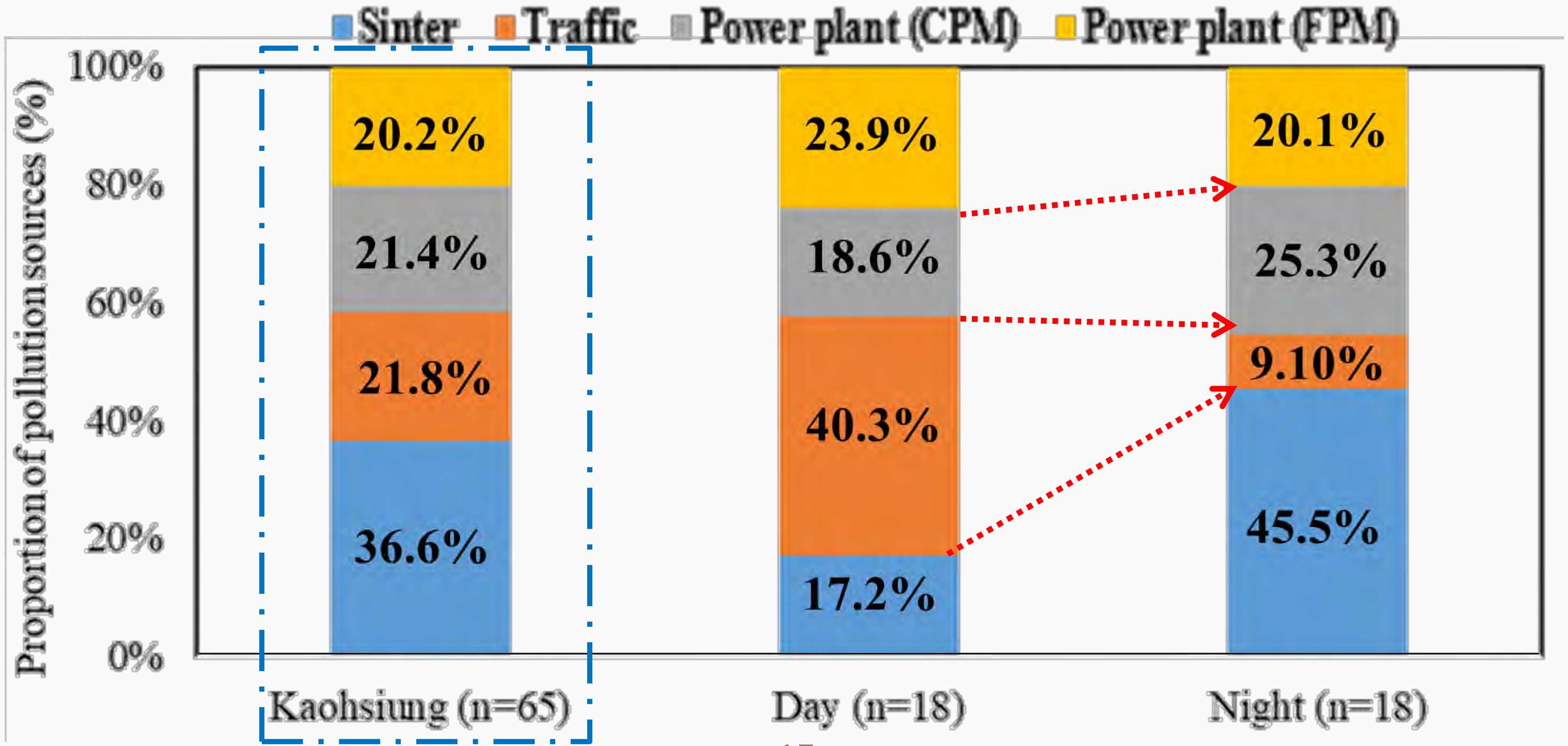
PAHs congener distribution during daytime and nighttime



- 2-rings ~ 5-rings (Petroleum 、 Fossil Fuels)
  → Day > Night

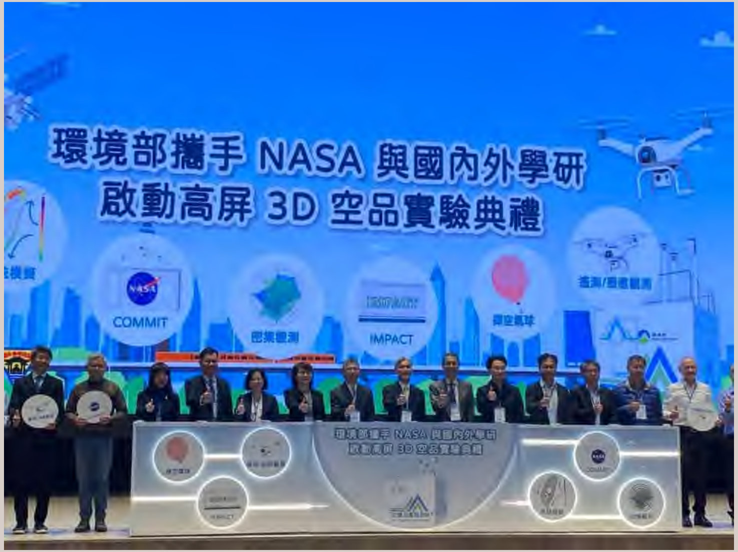
- 6-rings (Industrial 、 Traffic)
  → Night > Day

The result of PMF in atmospheric PAHs



Conclusions

- The $PM_{2.5}$ sampling results show that concentration is slightly higher at the traffic site, whereas PAHs concentration is higher at the industrial site.
- At both the industrial site and the traffic site, the concentration of $PM_{2.5}$ is higher during the daytime, while the concentration of PAHs is higher during the nighttime.
- The distribution of PAHs congeners shows that DBalP contributes the most at both sites, and the primary contributors during the daytime are two-rings to five-rings species, while during nighttime, six-rings species are the main contributors.
- The PMF results shows that the primary pollution source in Kaohsiung is sinter, with traffic being the main daytime pollution source and the sinter is the main source during nighttime.
- The oxidative potential (OP) results show that OPv is higher during the daytime, while OPm is higher during nighttime at both sampling sites.



Thanks For Listening

Prof. Kai Hsien Chi

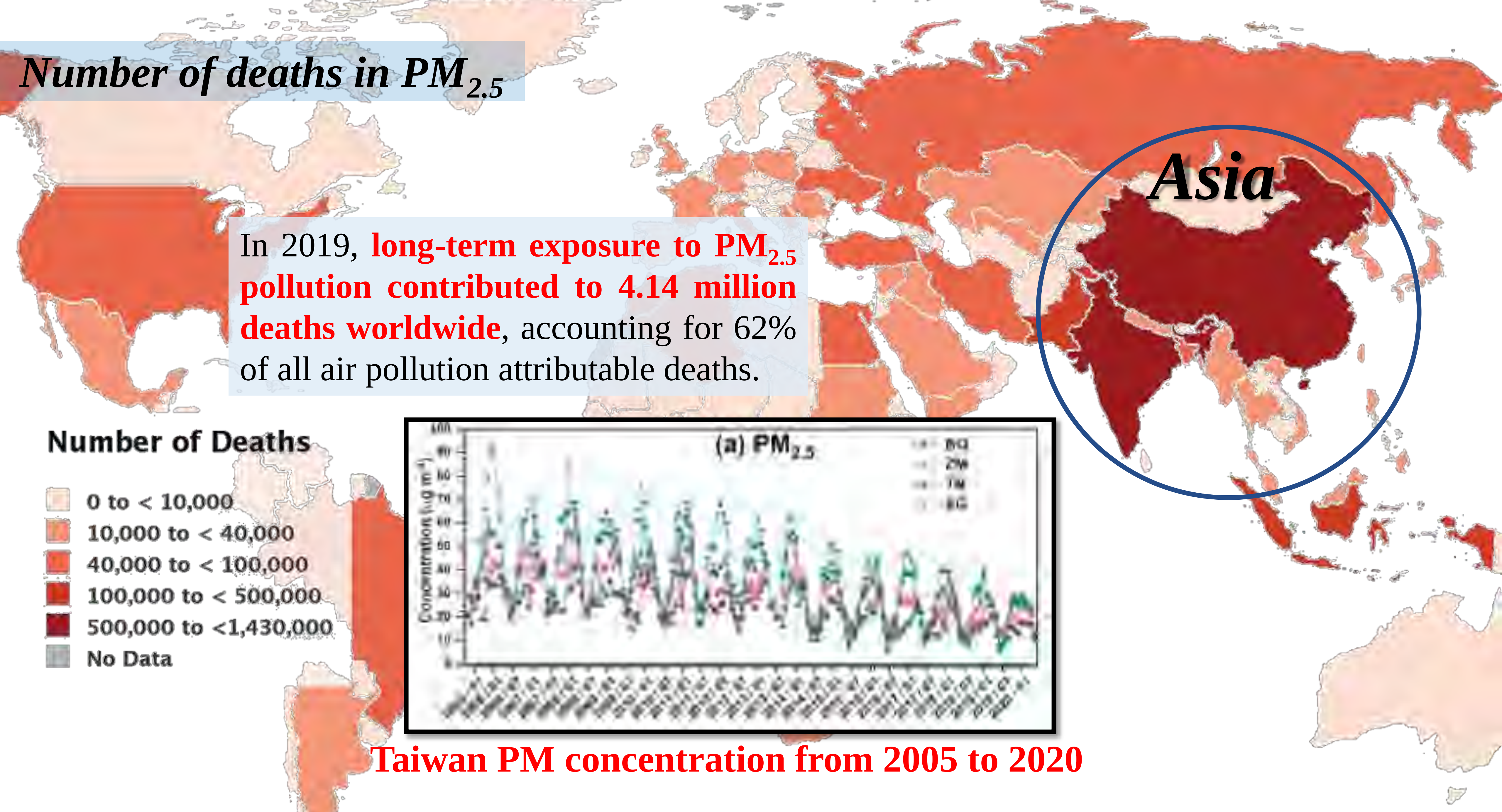
Contact: khchi@nycu.edu.tw

The Characteristics of POPs during Events and Non-events in Different Asian Cities

Kai Hsien Chi[1], Charles C.-K. Chou[2], Sheng-Lun Lin[3], Lodoisamba Sereeter[4], Yuan Cheng Hsu[5] Neng-Huei Lin[6] and <u>Shih Yu Pan[1*]</u>

1Institute of Environmental and Occupational Health Sciences, National Yang Ming Chiao Tung University, Taipei 112, Taiwan.
2Research Center for Environmental Changes, Academia Sinica, Taipei 115, Taiwan.
3Department of Environmental Engineering, National Cheng Kung University, Tainan, 70101, Taiwan.
4Environmental Engineering, German-Mongolian Institute for Resources and Technology (GMIT), Ulaanbaatar, Mongolia.
5National Environmental Research Academy, Ministry of Environment, Taoyuan, 330, Taiwan.
65Department of Atmospheric Sciences, National Central University, Taoyuan, 32001, Taiwan

Number of deaths in $PM_{2.5}$



In 2019, **long-term exposure to $PM_{2.5}$ pollution contributed to 4.14 million deaths worldwide**, accounting for 62% of all air pollution attributable deaths.

Taiwan PM concentration from 2005 to 2020

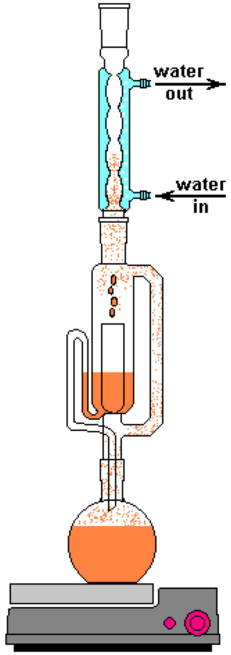
Numbers of deaths attributable to $PM_{2.5}$ in 2019 (State of Global Air); (Chuang, Ming-Tung, et al., 2021)

The map of ambient air sampling sites
Ulaanbaatar, Mongolia
-Sep., 2022 to Mar., 2024
-Dust storm: 29, Sep., 2022
Beijing, China
-Apr., 2023 to Mar., 2024
-Dust storm: 12, Mar., 2023
Kaohsiung, Taiwan
-Feb. to Mar., 2024
-LRT: 09, Mar., 2024
-Local: 28-29, Mar., 2024
Chiang Mai, Thailand
-Mar., 2019
Hanoi, Vietnam
-Oct., 2019
20191007
Russia
Mongolia
China
North Korea
South Korea
Japan
Turkey
Cyprus
Syria
Lebanon
Israel
Jordan
Iraq
Iran
Afghanistan
Pakistan
Kuwait
Bahrain
Qatar
Saudi Arabia
UAE
Nepal
Bhutan
Bangladesh
India
Myanmar
Laos
Thailand
Cambodia
Philippines
Indonesia
Maldives
N
0 km
1000 km
2000 km
3000 km

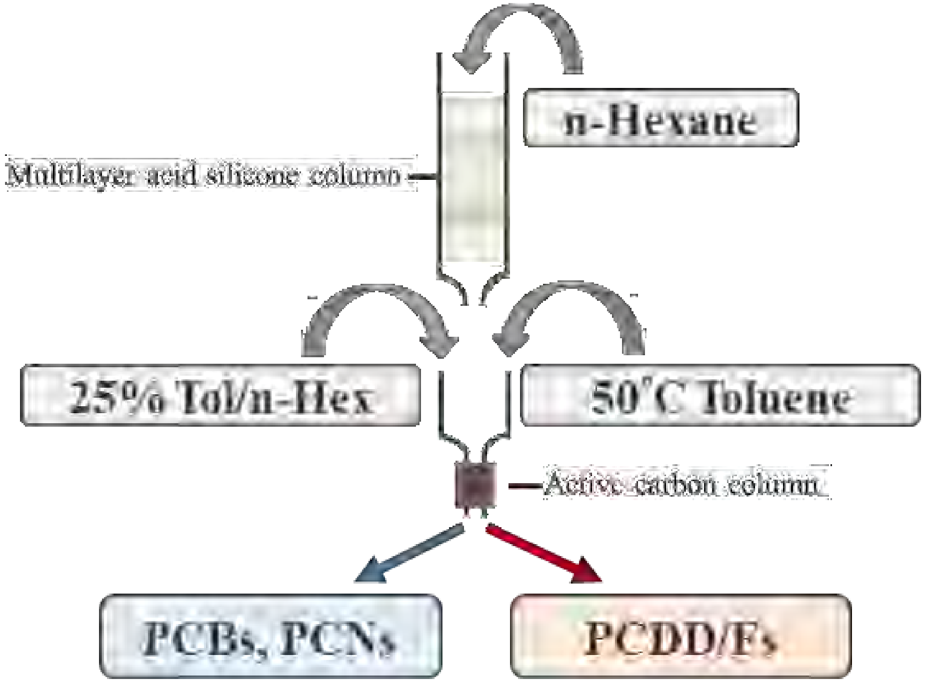
Chemical analysis of PCDD/Fs, PCBs and PCNs

1. The flow rate was set up on **225 - 1000 L/min** and the total volume of TSP and $PM_{2.5}$ were larger than 1,000 m^3 for a typical sampling duration of 24 hours.
2. In this study, **PCDD/Fs**, **PCBs** and **PCNs** were used for Soxhlet extraction (Toluene for 16-18 hr), then, clean up with silica gel. Moreover, we analyzed the **PCDD/Fs**, **PCBs** and **PCNs** within GC-MS/MS.

Sampling



Extraction



Purifying

Analysis

Exposure dose and cancer risk

USEPA

The tolerable limit

10^{-6}

Exposure dose

$$LADD_{inh} = \frac{C \times IR_{inh} \times AF_{inh}}{BW} \times \frac{ED}{AT}$$

$$LADD_{ingestion} = \frac{C \times IR_{ingestion} \times AF_{ingestion} \times LFC}{BW} \times \frac{ED}{AT}$$

$$LADD_{skin\ absorption} = \frac{C \times M_S \times SA \times AF_{skin\ absorption}}{BW} \times \frac{ED}{AT}$$

	Age	Mean
Respiration rate (m^3 /day)	0-12	15.8
	12-18	15.8
	19-70	15.1
Skin surface area (cm^2)	0-12	16498
	12-18	
	19-70	
Weight (kg)	0-12	22.5
	12-18	56.9
	19-70	61.7
Drinking water (mL/kg/day)	0-12	187
	12-18	91.5
	19-70	195

(Planning and analysis for Taiwan People Exposure Factors Handbook,2016)

Cancer risk

$$Risk_{inh} = \frac{Dose_{air} \times CPF \times ASF \times ED}{AT \times FAH} = LADD_{inh} \times \ Slope\ Factor$$

$$Risk_{noninh} = \frac{Dose_{noninh} \times CPF_{oral} \times ASF \times ED}{AT} = LADD_{noninh} \times \ Slope\ Factor$$

POPs

CSF:130000

PAHs

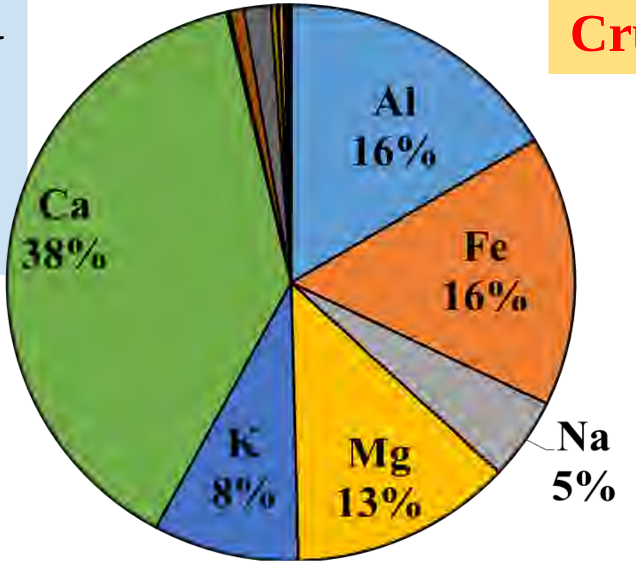
CSF_{inh}: 3.9

$CSF_{non\text{-}inh}$: 1

Distribution of Heavy Metal in PM in different Asian cities

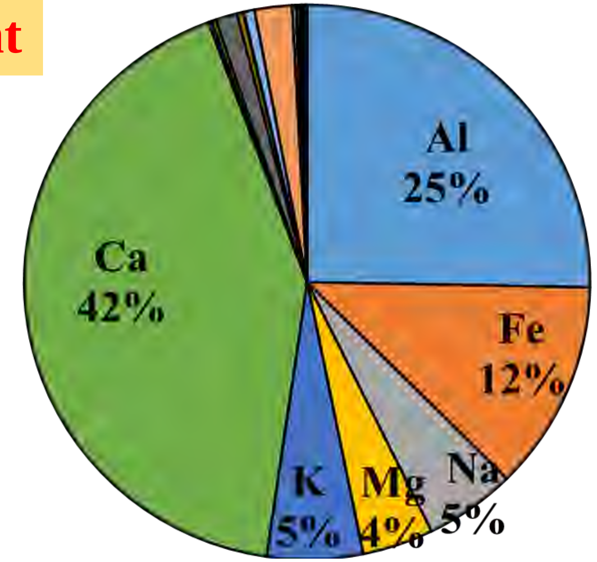
Crustal element

Beijing (n=6)



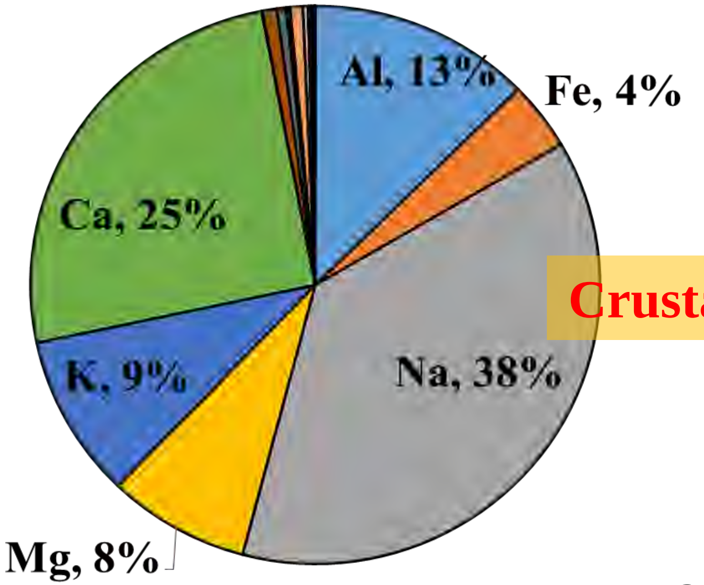
Metal Con. = 145 ± 74.1 μg/m^3

Ulaanbaatar (n=21)



Metal Con. = 21.1 ± 13.0 μg/m^3

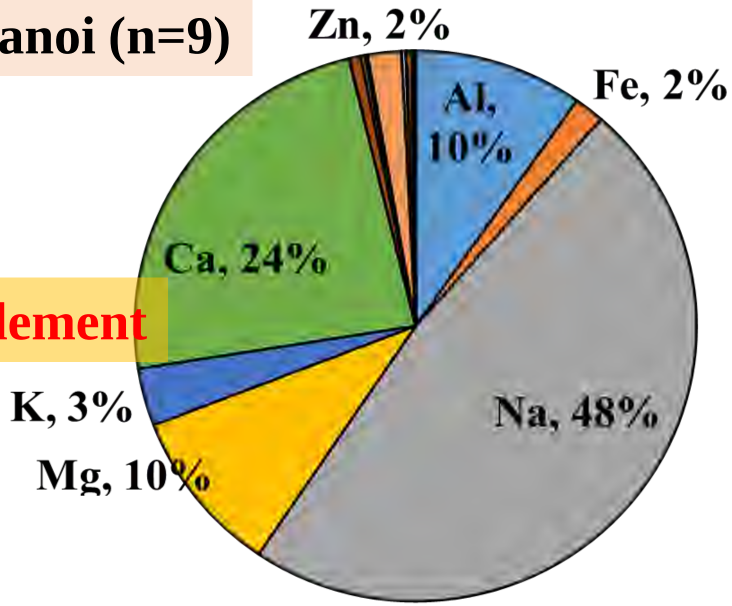
Chiang Mai (n=16)



Metal Con. = 32.7± 21.2 μg/m^3

Crustal element

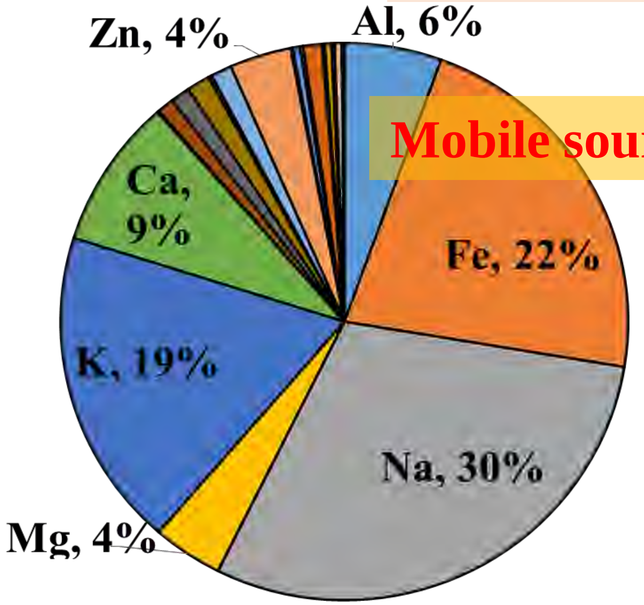
Hanoi (n=9)



Metal Con. = 64.4 ± 1.83 μg/m^3

Taipei (n=49)

Mobile source



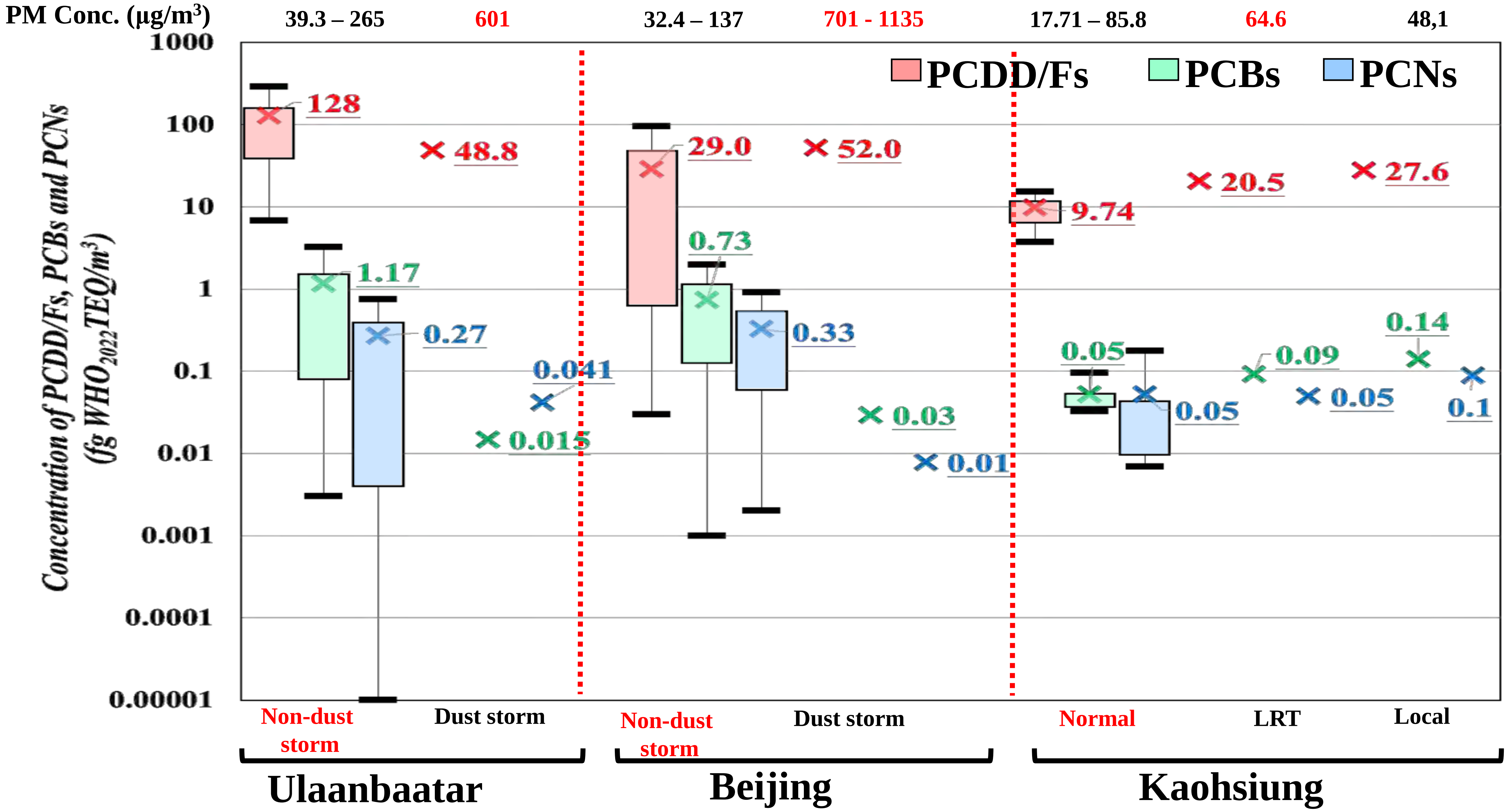
Metal Con. = 0.72 ± 0.14 μg/m^3

Enrichment factor of metal in ambient PM

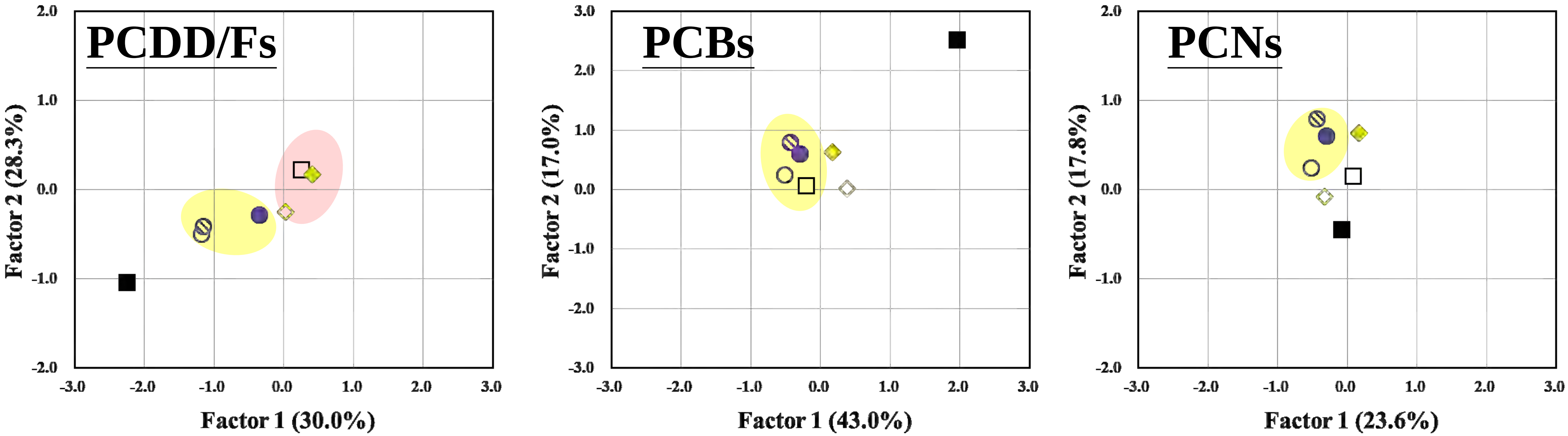
Source	Metal	Beijing	Ulaanbaatar	Chiang Mai	Hanoi	Taipei
Crustal	Mn	0.27	0.09	0.10	0.03	1.31
Crustal	K	0.30	-0.08	0.50	0.14	1.12
Crustal	Na	0.02	-0.15	0.91	1.24	1.28
Crustal	Ca	0.75	0.54	0.57	0.68	0.50
	Cs	0.62	0.79	0.47	0.32	1.25
Coal fired	Cu	-1.73	-0.69	-1.55	-1.74	0.22
	V	0.16	-0.15	-0.20	-0.40	1.22
Industrial	Cr	0.54	0.30	0.70	0.85	1.74
Traffic	Ni	0.42	0.23	0.36	0.07	1.57
	Zr	0.31	0.54	0.67	0.60	1.57
	Rb	0.18	0.08	0.38	0.02	0.97
	Ba	1.09	0.32	1.09	1.11	1.52
	Tl	0.78	0.86	0.92	0.89	2.46
	As	1.34	1.80	1.40	1.75	2.97
Burning	Pb	0.94	1.69	1.40	2.26	3.09
Burning	Cd	1.46	1.96	1.95	2.32	3.37
Traffic	Zn	1.39	2.01	1.82	2.35	2.86
Traffic	Mo	2.55	2.77	3.13	3.15	2.96
Traffic	Sn	1.27	1.24	1.56	1.99	3.47
Traffic	Sb	1.75	2.33	2.40	2.58	4.11
	Se	2.79	2.67	2.75	2.91	4.19

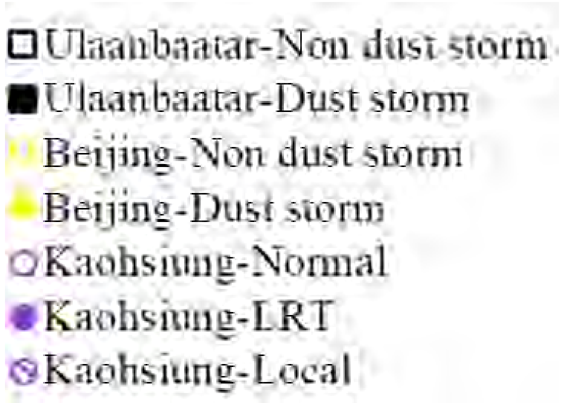
Color scale: −2 to 5

The concentration of PM and POPs during events and non-events



The PCA of PCDD/Fs, PCBs and PCNs

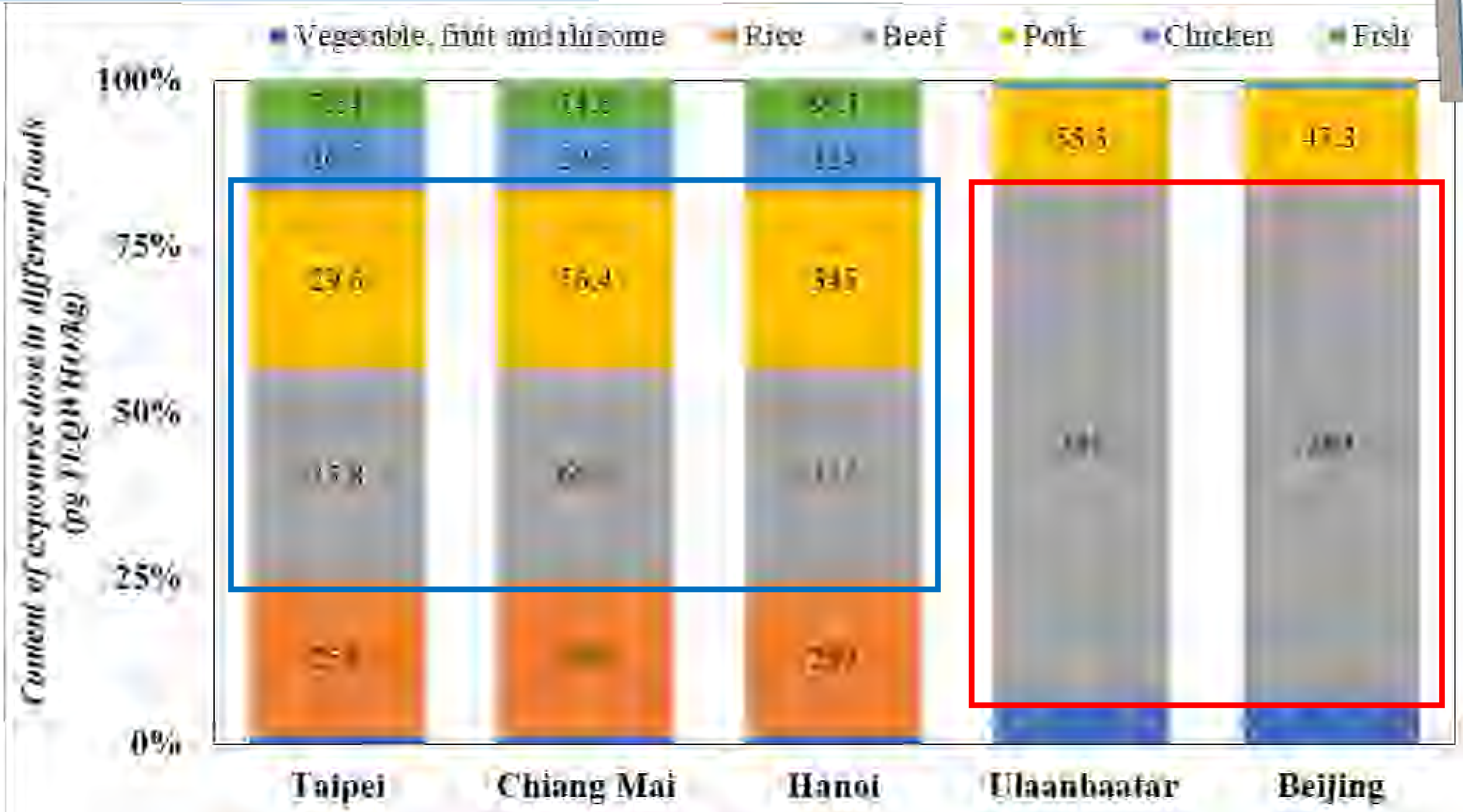




1. In both Ulaanbaatar and Beijing, **low-chlorinated congeners of PCDD/Fs** were predominant.
2. In Beijing, the **major PCB congeners** identified during non-dust storm periods were PCB 118 and PCB 105.
3. Additionally, **low-chlorinated PCN congeners** were found in Kaohsiung.

Health impact assessment

USEPA
The tolerable limit
10^{-6}



Taipei	Chiang Mai	Hanoi	Ulaanbaatar	Beijing
Total Risk 2.95E-07	Total Risk 1.06E-06	Total Risk 5.87E-06	**Total Risk 5.47E-05**	**Total Risk 1.03E-04**

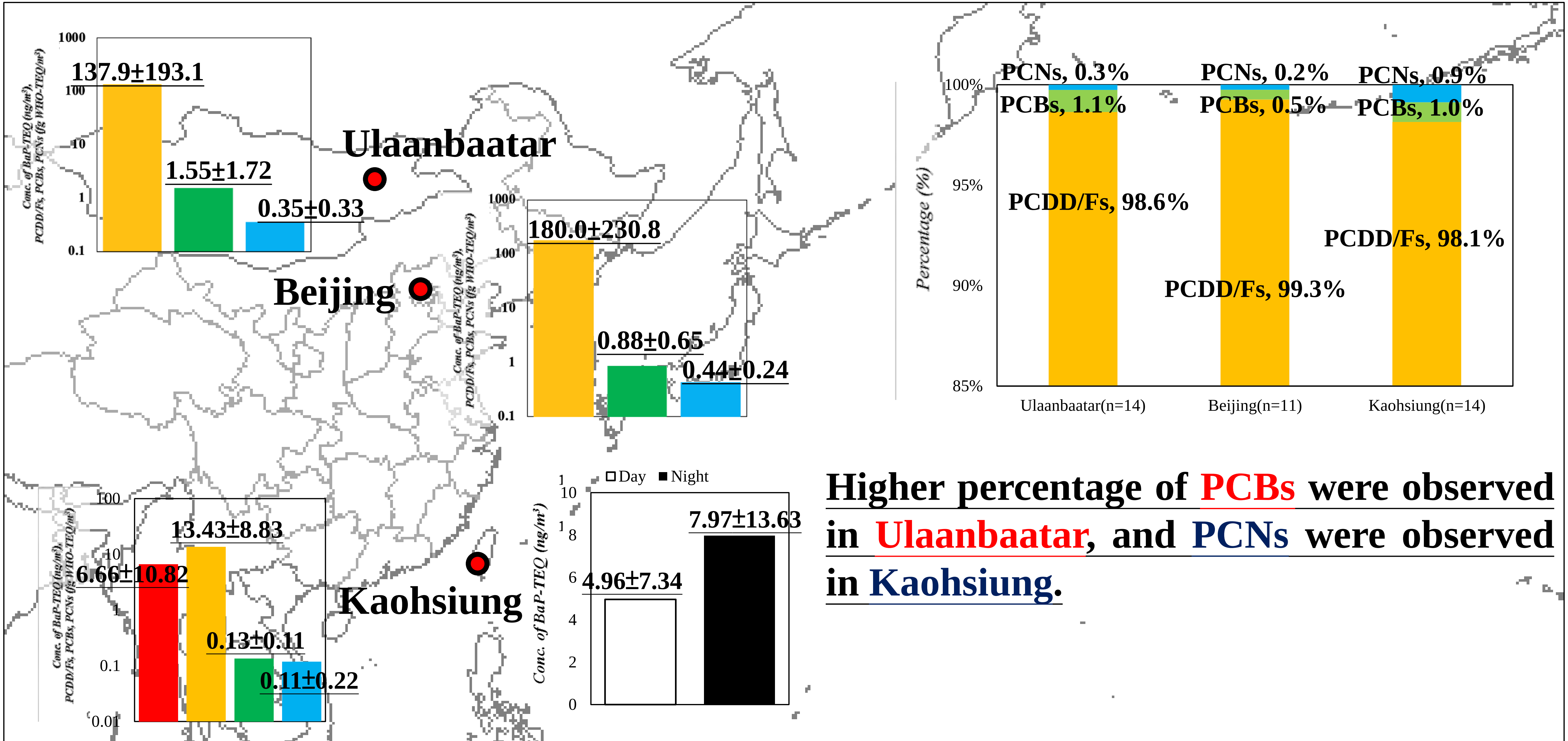
Summary

1. Air pollution in **Ulaanbaatar is significantly higher than in Beijing and Taiwan**, particularly in terms of the toxic equivalent concentrations of PCDD/Fs, PCBs, and PCNs. **The major anthropogenic emission sources in those Asian countries were significantly different**.
2. The component of metal in Beijing and Ulaanbaatar are similar, as are those in Chiang Mai and Hanoi. Additionally, **mobile sources contribute to the metal content in Taipei**.
3. During the dust storm in **Ulaanbaatar**, where significant coal burning was observed, **the concentration of TSP increased, while the concentrations of PCDD/Fs, PCBs, and PCNs decreased**. In contrast, **the concentrations of PCDD/Fs, PCBs, and PCNs increased during events in Beijing and Kaohsiung**, indicating the presence of different pollution sources.
4. The health risk assessments indicate that both the lifetime inhalation and non-inhalation carcinogenic risks in **Ulaanbaatar and Beijing exceed the acceptable risk level** set by the USEPA (1×10^{-6}).

Thank you for attention!

Dr. Shelly, S.-Y., Pan
Email: shelly.pan923@hotmail.com

Concentration of chemical compounds in different countries (Sampling period: 2024/2/2~3/28)

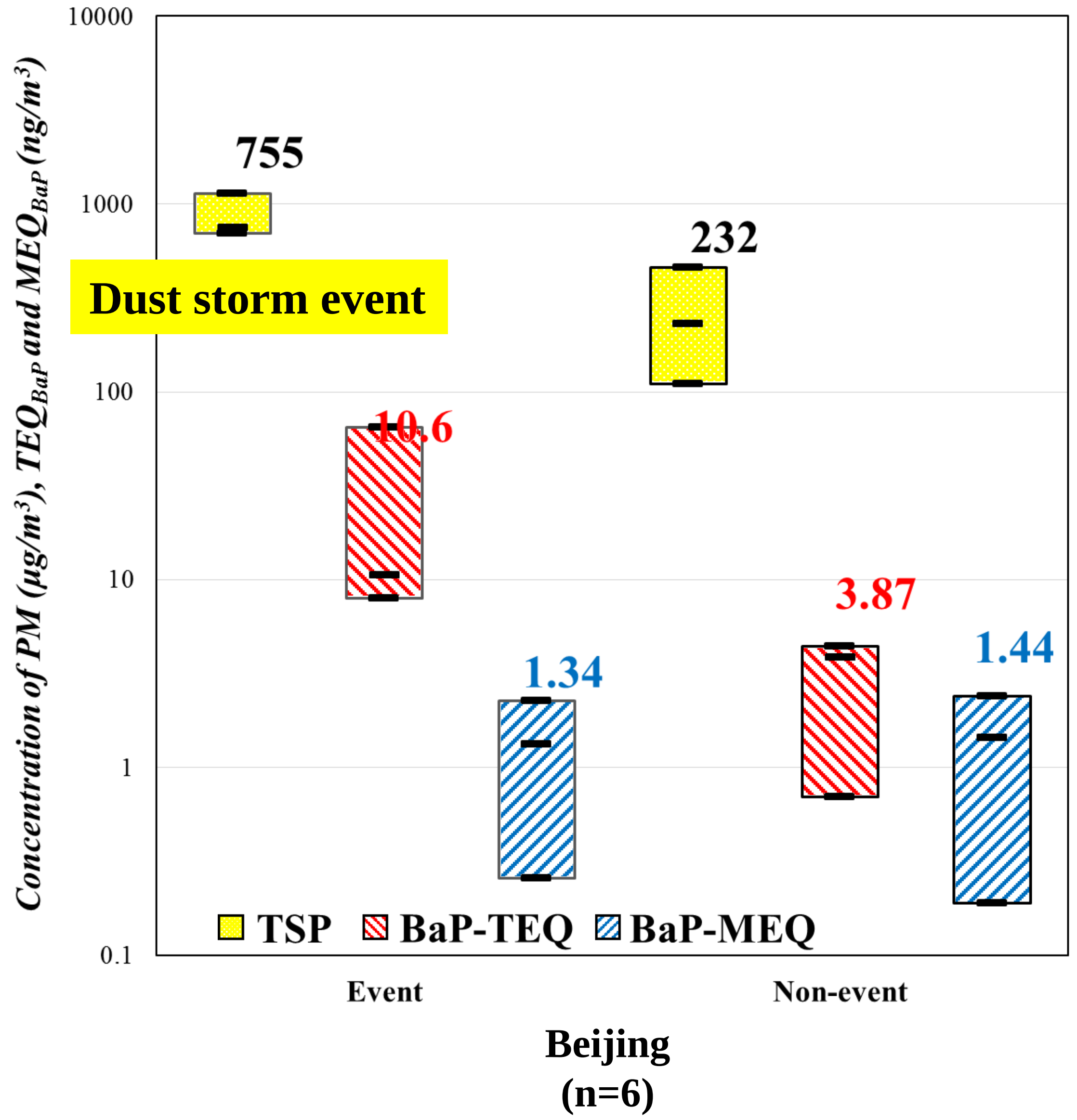


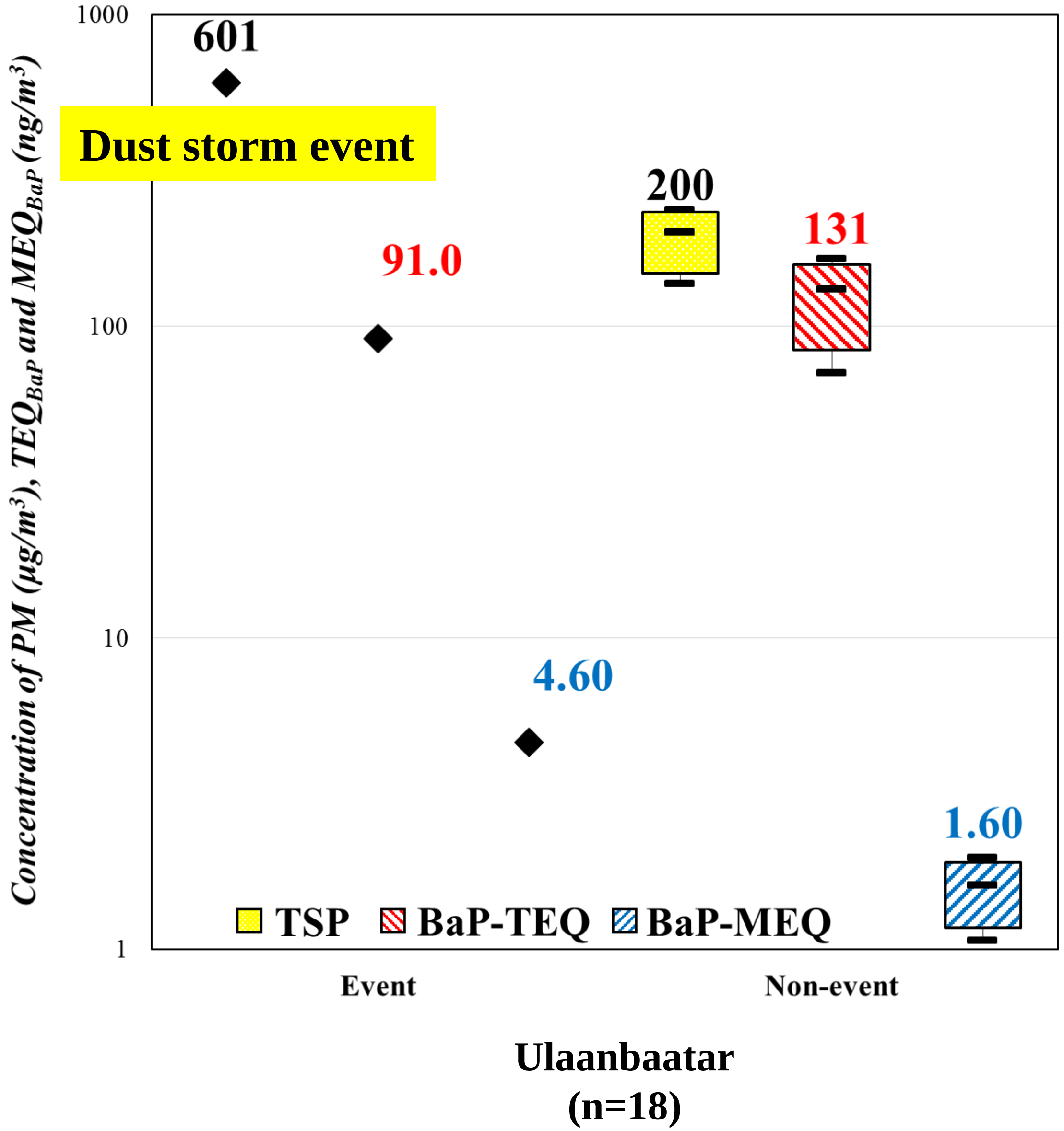
Higher percentage of PCBs were observed in Ulaanbaatar, and PCNs were observed in Kaohsiung.

PAHs (ng/m^3) PCDD/Fs (fg WHO-TEQ/m^3) PCBs (fg WHO-TEQ/m^3) PCNs (fg WHO-TEQ/m^3)

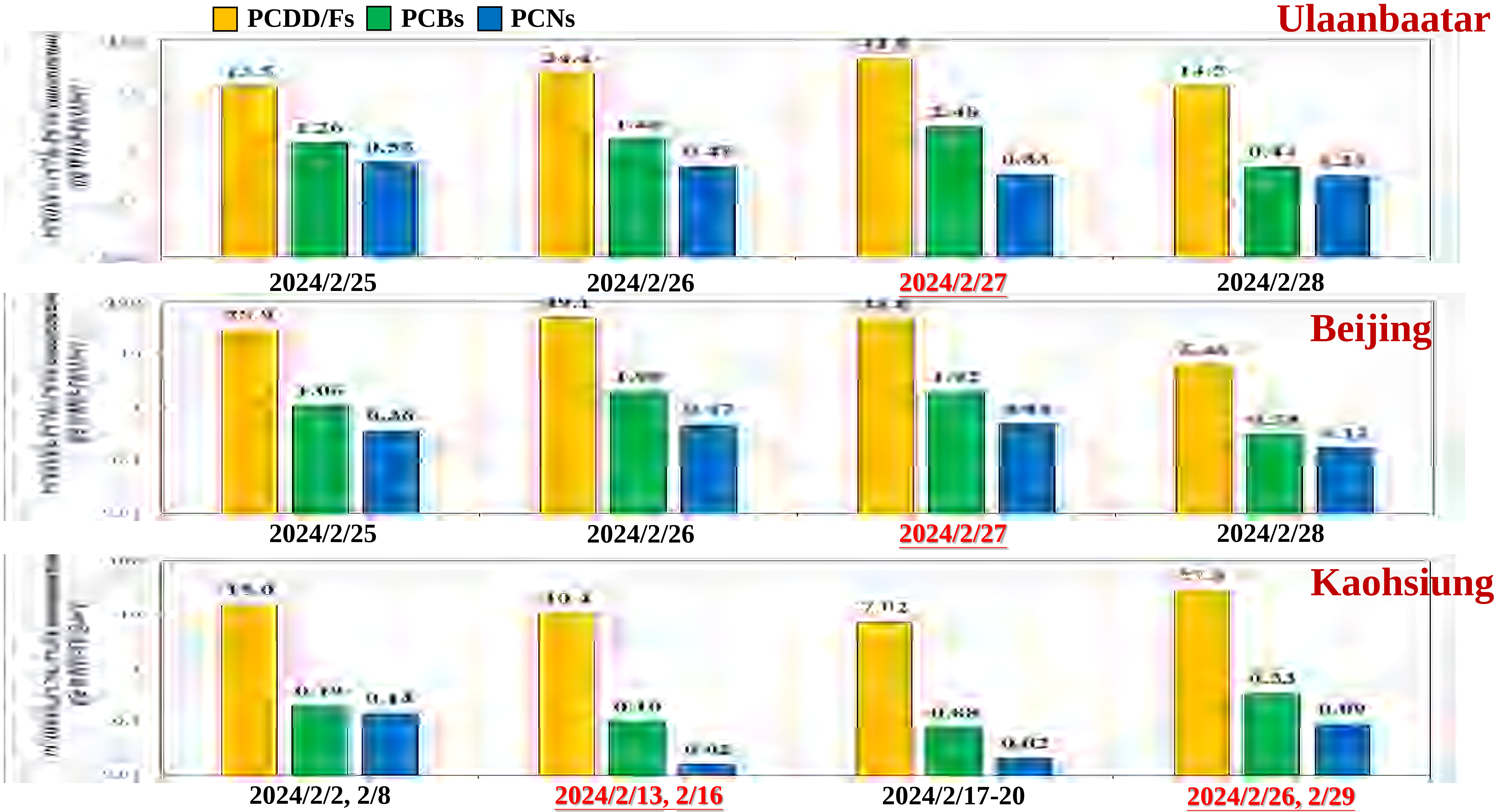
Previous study: Concentration of particles and PAHs in Beijing and Ulaanbaatar

Higher concentration of TSP was observed during dust storm from 2022 to 2023.

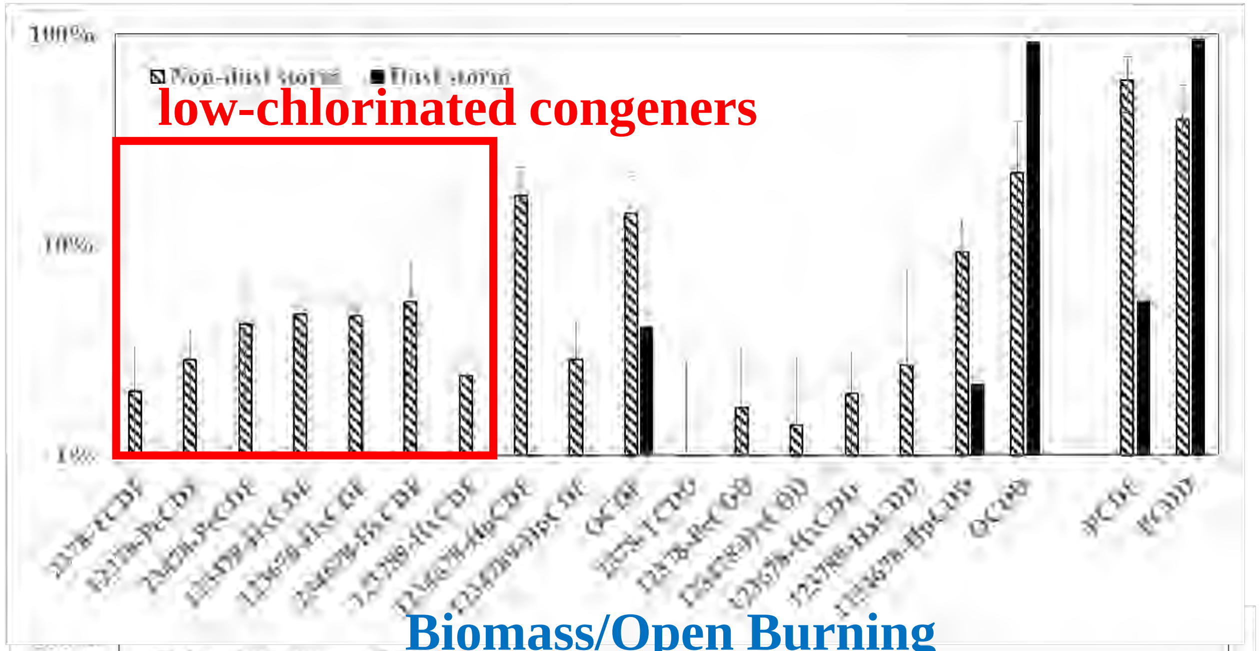


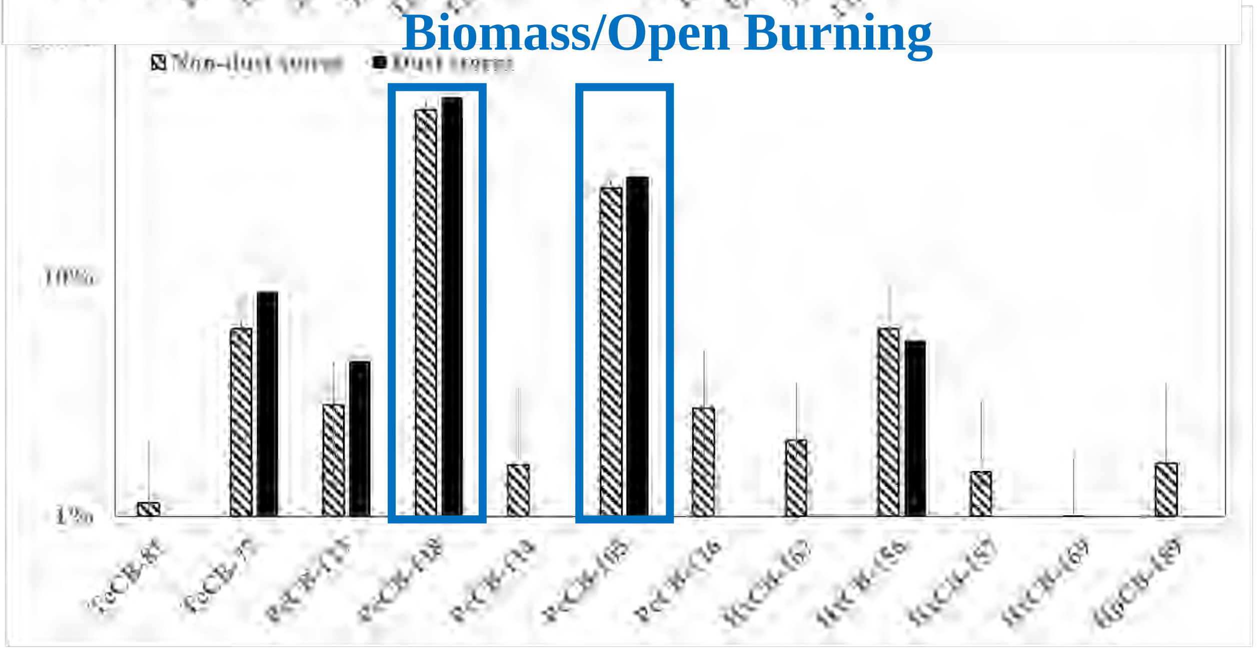


Time-series analysis of chemical compounds in different countries



The congener of ambient PCDD/Fs, PCBs and PCNs in Ulaanbaatar

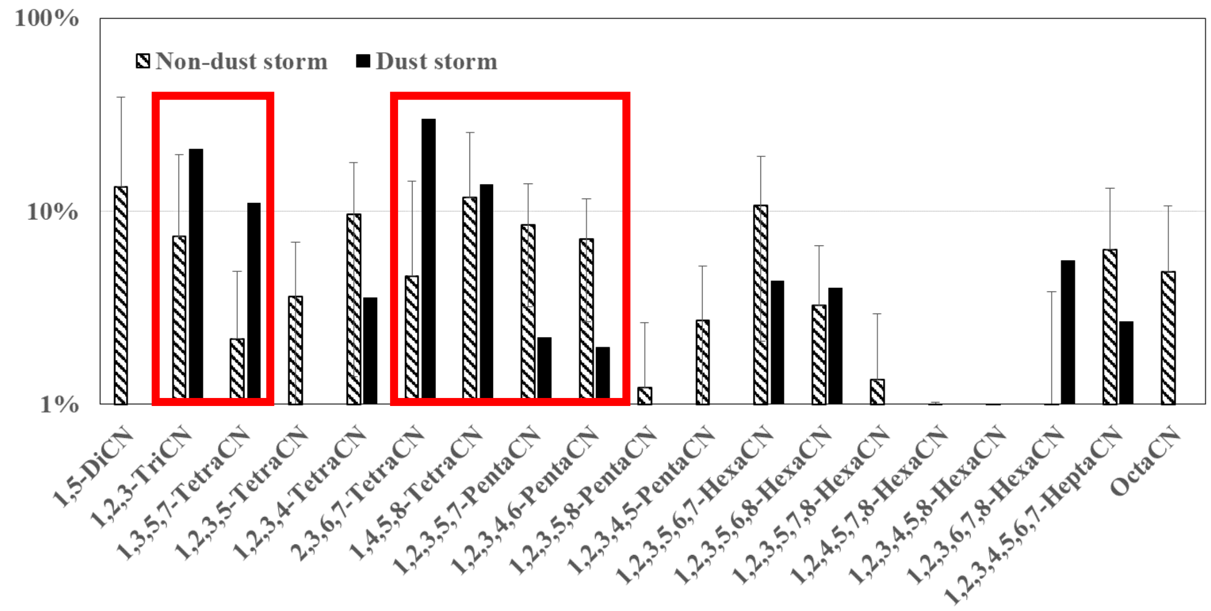




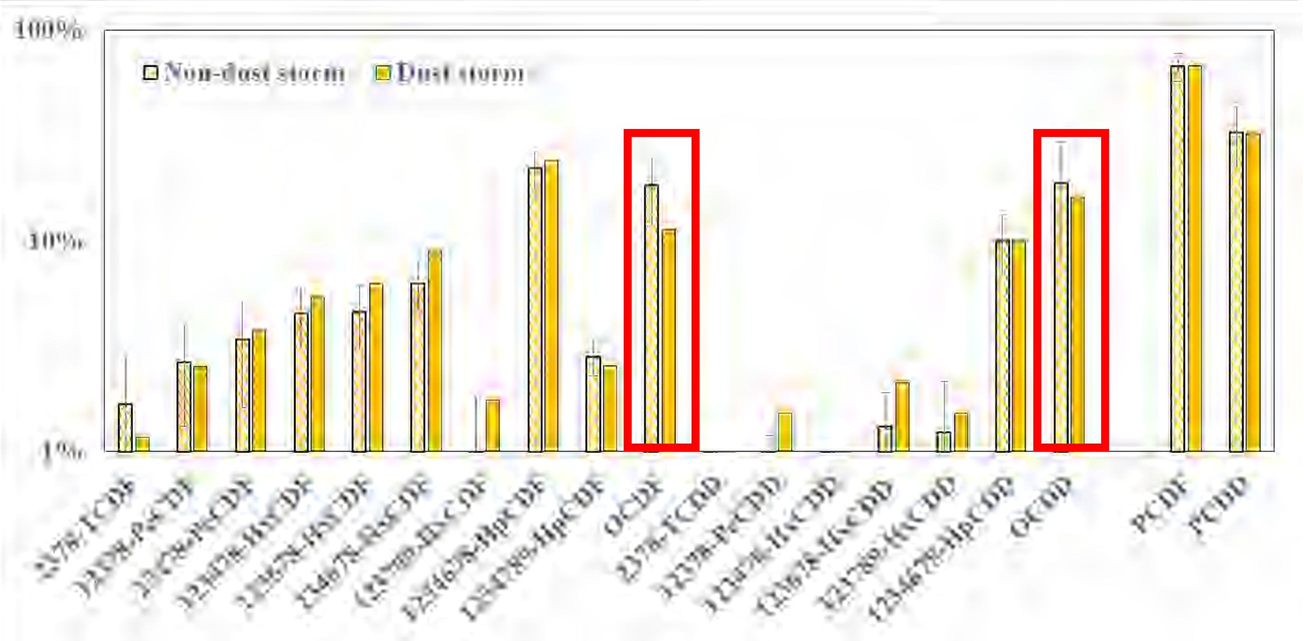
- **PCDD/Fs ratio: 17.5 (Dust storm); 0.684 (non-event)**

-Less than 1: combustion or anthropogenic emission sources

- PCBs: **PeCB-118** and **PeCB-105**
- PCNs: **low-chlorinated congeners.**



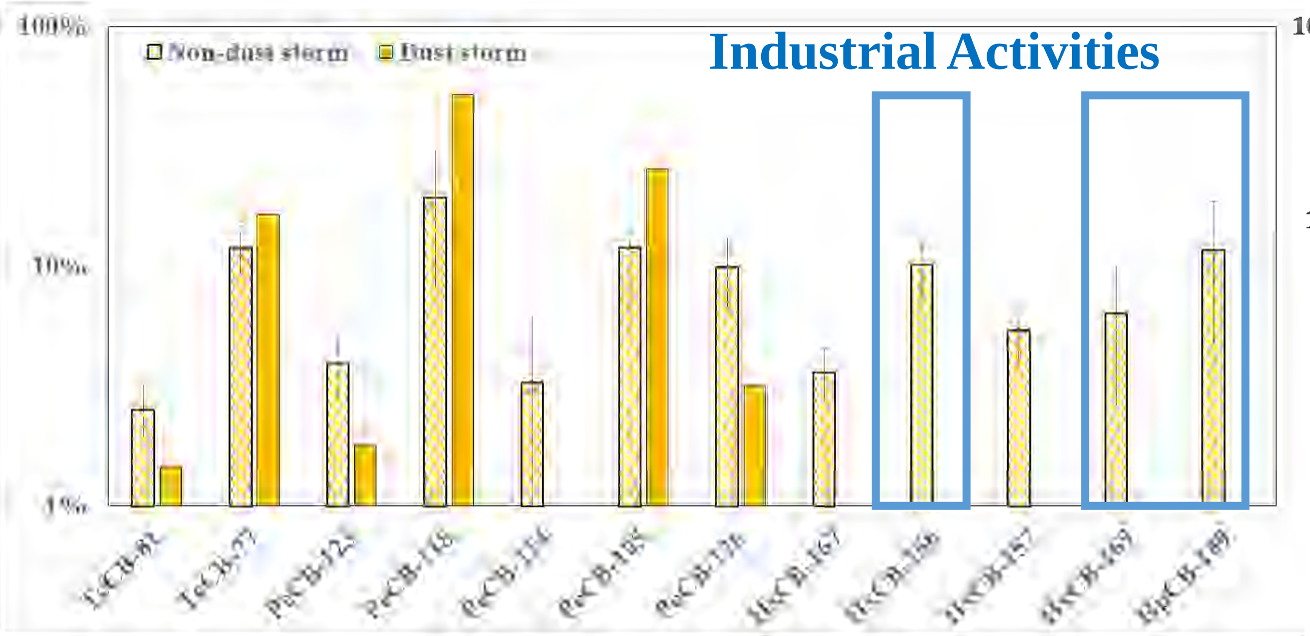
The congener of ambient PCDD/Fs, PCBs and PCNs in Beijing

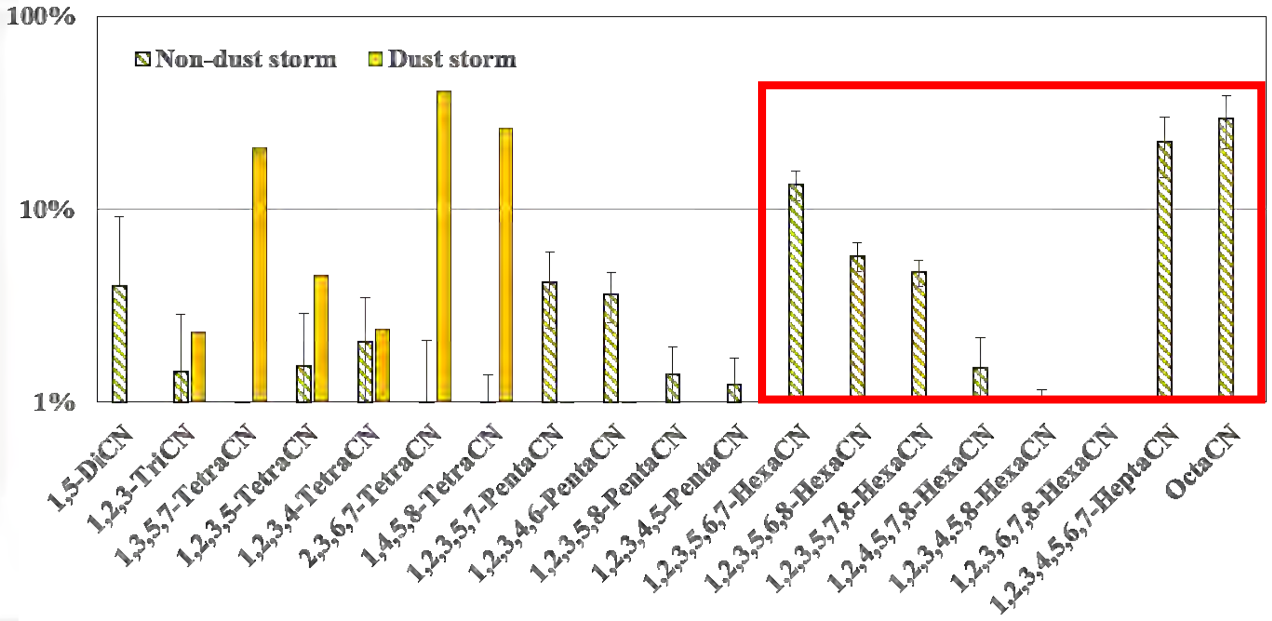


- **PCDD/Fs: PCDF > PCDD**

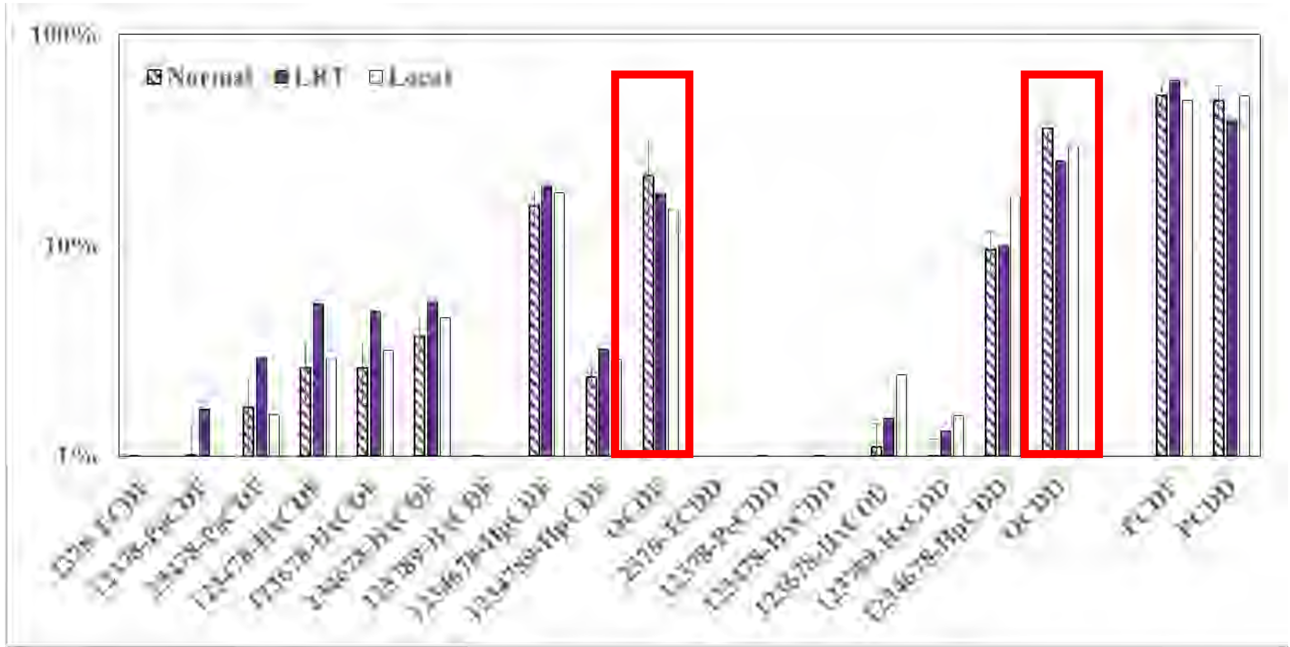
-Less than 1: combustion or anthropogenic emission sources

- PCBs: **PeCB-156**, **HxCB-169** and **HpCB-189**
- PCNs: **high-chlorinated congeners.**





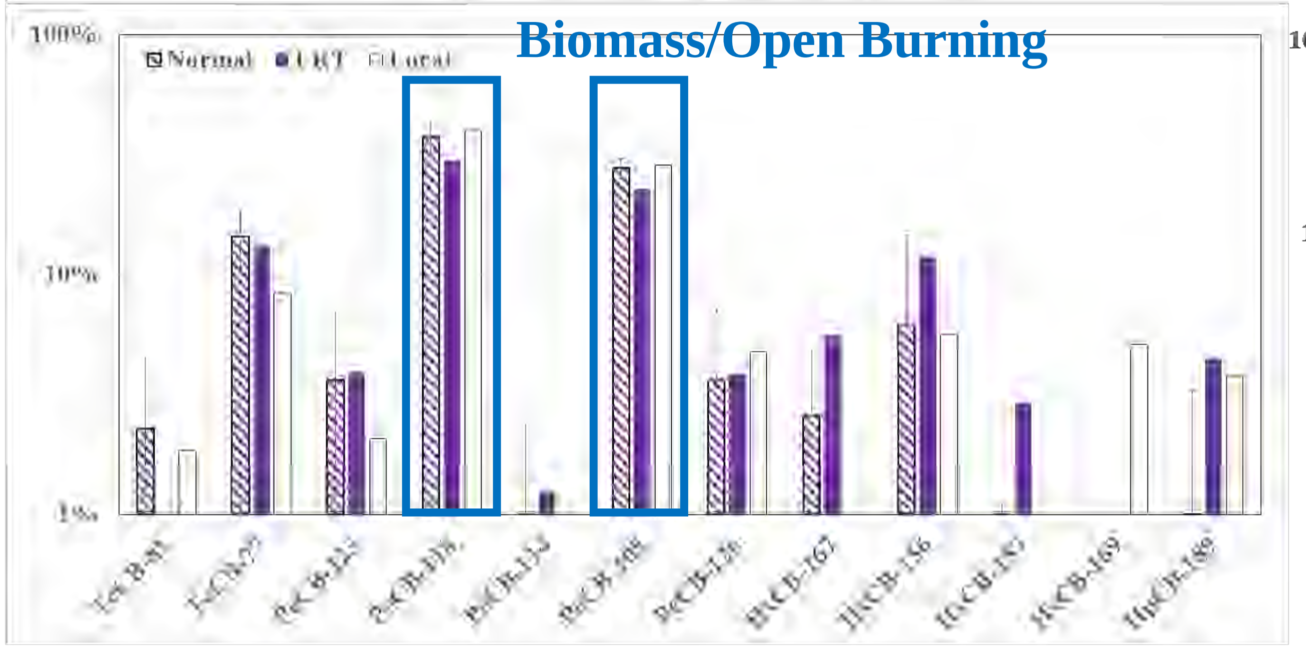
The congener of ambient PCDD/Fs, PCBs and PCNs in Kaohsiung

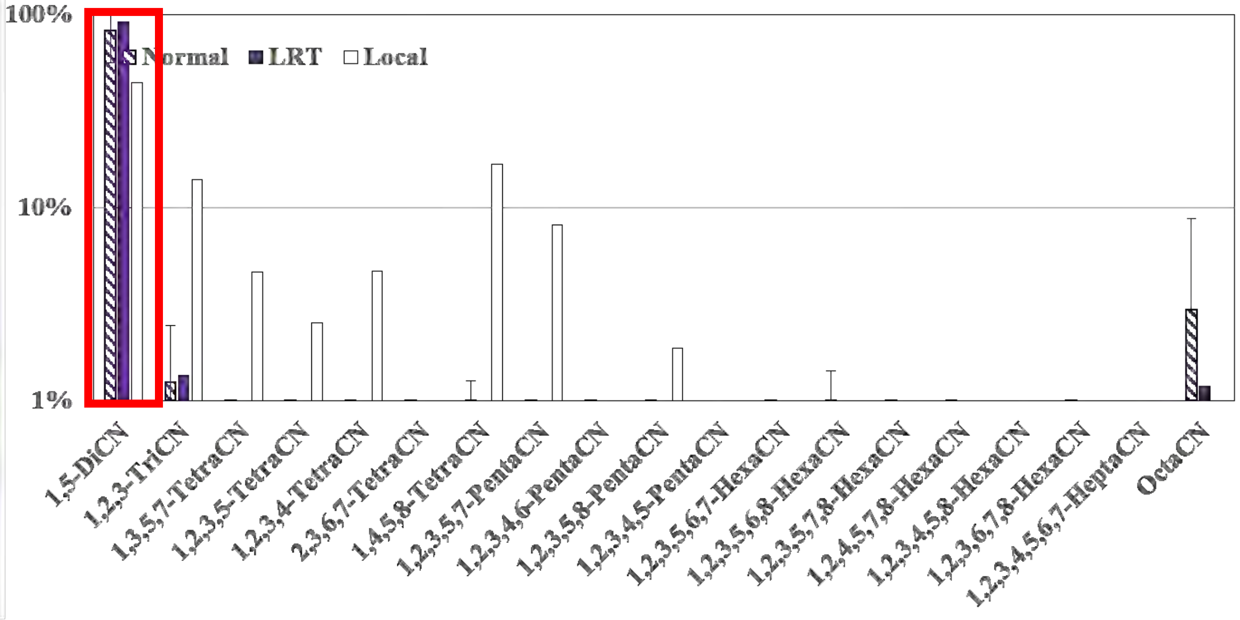


- **PCDD/Fs: PCDF > PCDD**

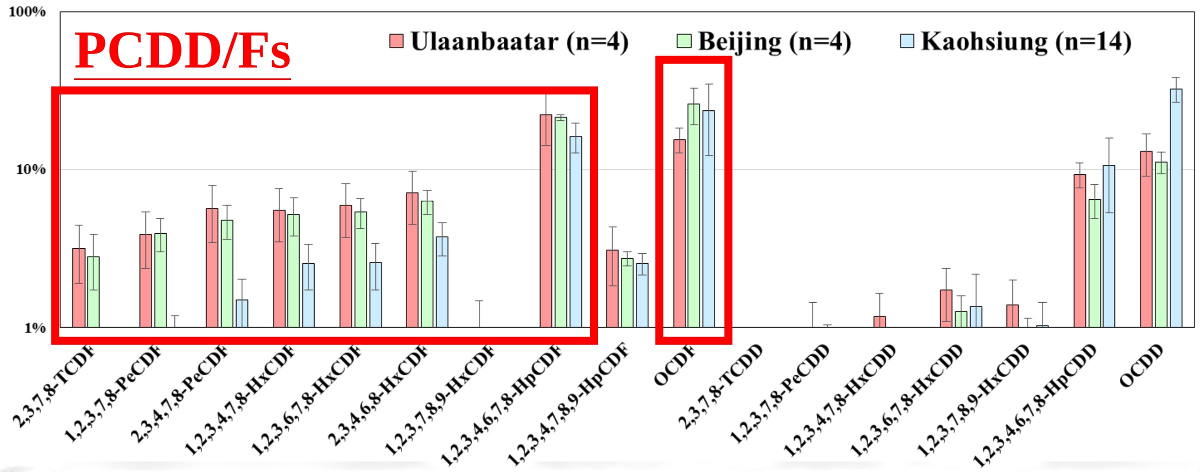
-Less than 1: combustion or anthropogenic emission sources

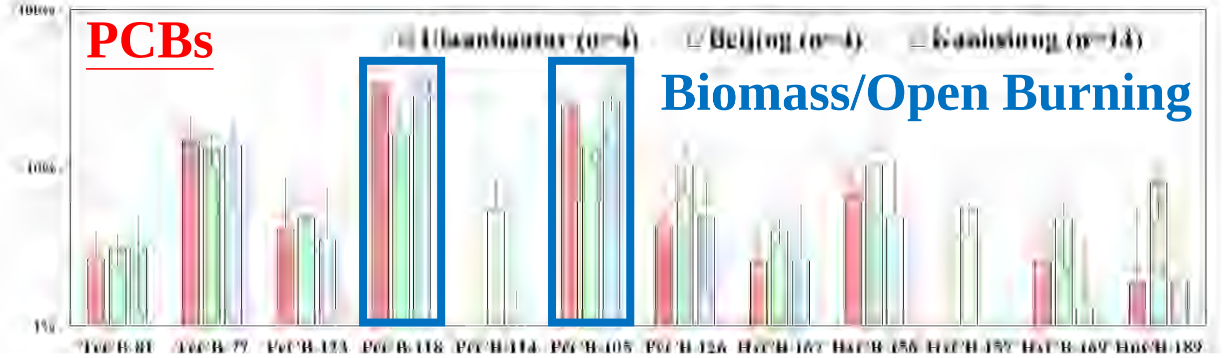
- PCBs: **PeCB-118** and **PeCB-105**
- **PCNs: low-chlorinated congeners.**

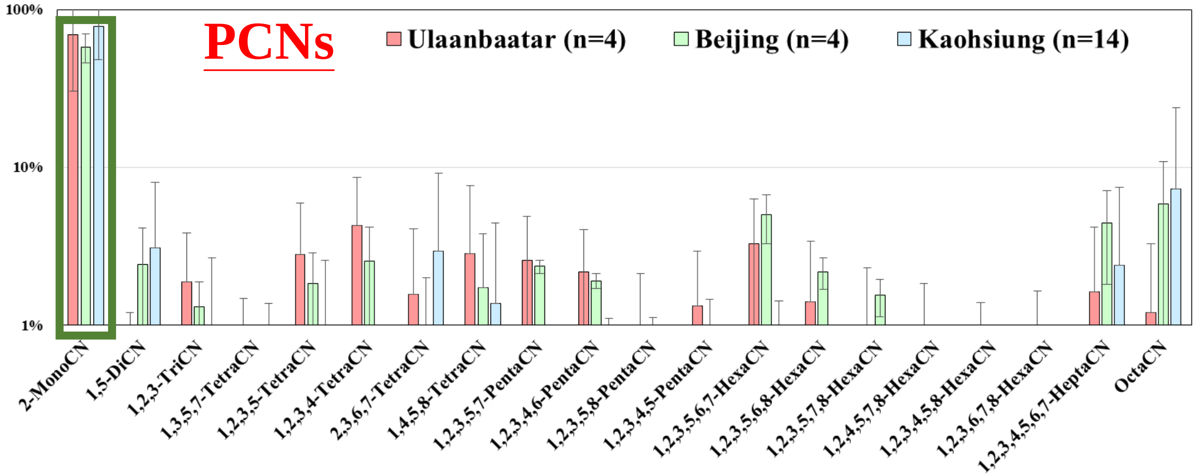




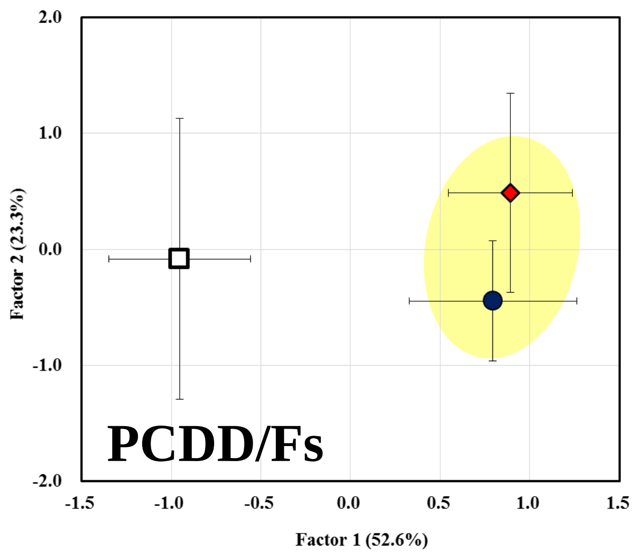
Congener profile and PCA result of PCDD/Fs, PCBs, PCNs



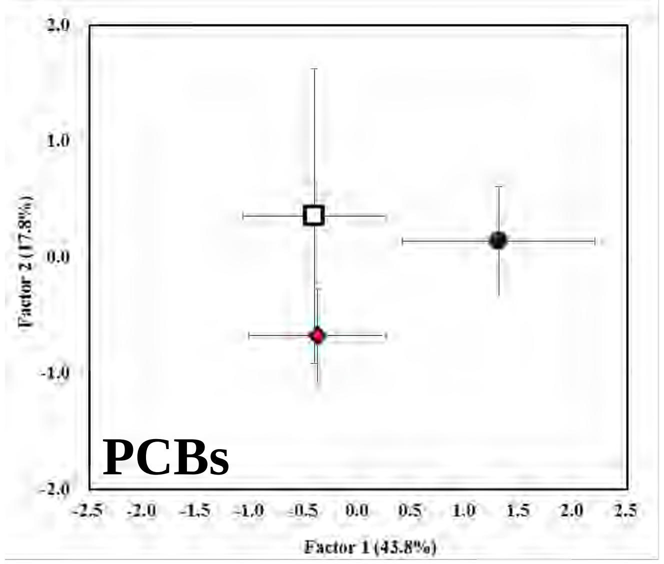


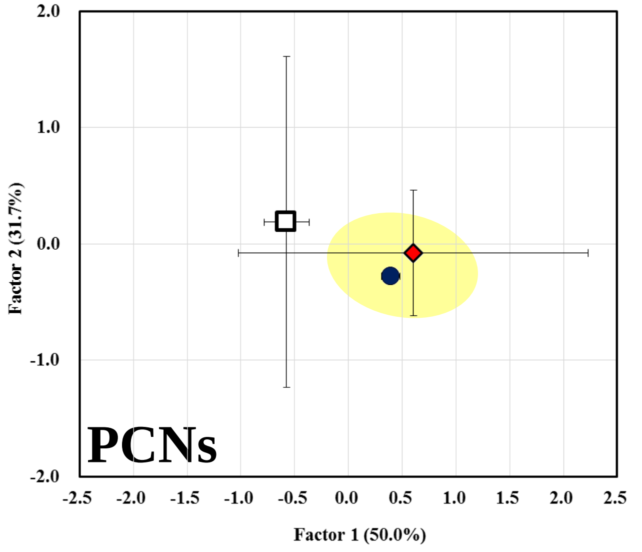


- **PCDD/Fs: more than 70% ΣPCDF (72.4 – 78.5%) in UB and Beijing; 53.8% ΣPCDF in Kaohsiung.**
- **PCBs and PCNs: Similar congener of PCBs and PCNs were observed in Asian countries.**



Different anthropogenic emission sources





□Kaohsiung ◆Ulaanbaatar ●Beijing

Estimating POPs concentrations in various media from atmospheric levels

	Ulaanbaatar			**Beijing**			**Taipei**		
	PCDD/Fs	PCBs	PCNs	PCDD/Fs	PCBs	PCNs	PCDD/Fs	PCBs	PCNs
Ambient air ($fg\ TEQ_{WHO}/m^3$)	128±154	1.32±1.60	0.302±0.340	107±178	0.878±0.645	0.441±0.244	2.25±2.14	0.013±0.021	0.018±0.019
Ambient deposition ($pg\ TEQ_{WHO}/m^2$-d)	22.1±26.6	0.228±0.277	0.052±0.059	18.5±30.8	0.152±0.112	0.076±0.042	0.388±0.042	0.002±0.003	0.003±0.003
Soil ($pg\ TEQ_{WHO}/g$)	6.67E-01 ±7.95E-01	6.72E-03 ±8.16E-03	1.54E-03 ±1.71E-03	6.05E-01 ±1.01E+00	4.97E-03 ±3.65E-03	1.02E-04 ±5.65E-05	1.27E-02 ±1.21E-02	7.32E-05 ±1.18E-04	1.01E-04 ±1.07E-04
Water ($pg\ TEQ_{WHO}/g$)	1.61E-04 ±1.92E-04	1.62E-06 ±1.97E-06	3.72E-07 ±4.13E-07	2.19E-05 ±3.65E-05	1.80E-07 ±1.32E-07	3.68E-09 ±2.04E-09	1.33E-08 ±1.27E-08	7.70E-11 ±1.24E-10	1.07E-10 ±1.13E-10

Unit: $pg\ TEQ_{WHO}/kg$	**Ulaanbaatar**			**Beijing**			**Taipei**		
	PCDD/Fs	PCBs	PCNs	PCDD/Fs	PCBs	PCNs	PCDD/Fs	PCBs	PCNs
Content of crops	2.59E-05 ± 3.10E-05	2.61E-07 ± 3.17E-07	5.98E-08 ± 6.69E-08	2.35E-05 ± 3.92E-05	1.93E-07 ± 1.42E-07	3.95E-09 ± 2.19E-09	4.92E-07 ± 4.69E-07	2.84E-09 ± 4.59E-09	3.94E-09 ± 4.17E-09
Content of rice	2.59E-05 ± 3.10E-05	2.61E-07 ± 3.17E-07	5.98E-08 ± 6.69E-08	2.35E-05 ± 3.92E-05	1.93E-07 ± 1.42E-07	3.95E-09 ± 2.19E-09	4.92E-07 ± 4.69E-07	2.84E-09 ± 4.59E-09	3.94E-09 ± 4.17E-09
Content of vegetable	25.4 ± 30.4	0.256 ± 0.311	0.059 ± 0.066	21.6 ± 36.0	0.177 ± 0.130	0.004 ± 0.002	0.453 ± 0.432	0.003 ± 0.005	0.004 ± 0.004
Content of beef	297 ± 356	2.99 ± 3.63	0.685 ± 0.766	258 ± 430	2.12 ± 1.56	0.043 ± 0.024	5.42 ± 5.16	0.031 ± 0.050	0.043 ± 0.046
Content of pork	54.6 ± 65.4	0.551 ± 0.669	0.126 ± 0.141	46.9 ± 78.1	0.385 ± 0.283	0.008 ± 0.004	0.986 ± 0.940	0.006 ± 0.010	0.008 ± 0.009
Content of poultry	2.96 ± 3.55	0.030 ± 0.036	0.007 ± 0.008	2.54 ± 4.23	0.021 ± 0.015	0.0004 ± 0.0002	0.053 ± 0.051	0.0003 ± 0.0005	0.0004 ± 0.0004
Content of fish	2.73 ± 3.27	0.028 ± 0.034	0.006 ± 0.007	2.35 ± 3.91	0.019 ± 0.014	0.0004 ± 0.0002	0.049 ± 0.047	0.0003 ± 0.0005	0.0004 ± 0.0004

Spatiotemporal Variations in Chemical Composition of Atmospheric Aerosols in the 2024 Kao-Ping Experiment Campaign (KPEx) in Southern Taiwan

Presenter: Ying I. Tsai

Ying I. Tsai[1], Chung-Shin Yuan[2], Chih-Chung Lin[3], Wei-Cheng Weng[1], Yu-Lun Tseng[2]

[1] Department of Environmental Engineering and Science, Chia Nan University of Pharmacy and Science, Taiwan

[2] Institute of Environmental Engineering, National Sun Yat-sen University, Taiwan

[3] Department of Environmental Science and Engineering, National Pingtung University of Science and Technology, Taiwan

R.A.P.A.T

Room for air pollution & aerosol technology

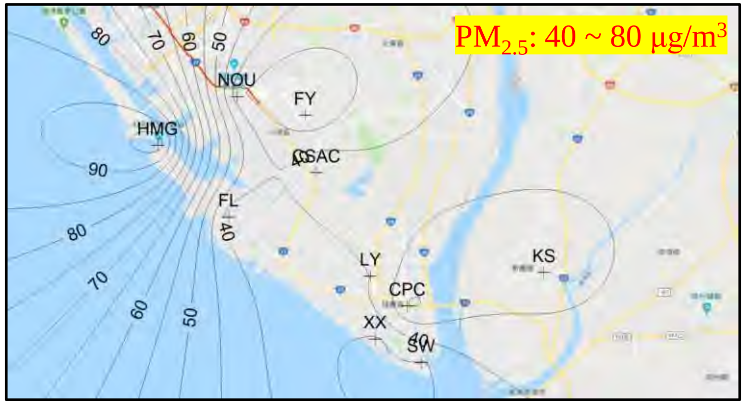
Chia Nan University of Pharmacy & Science

January 22, 2025

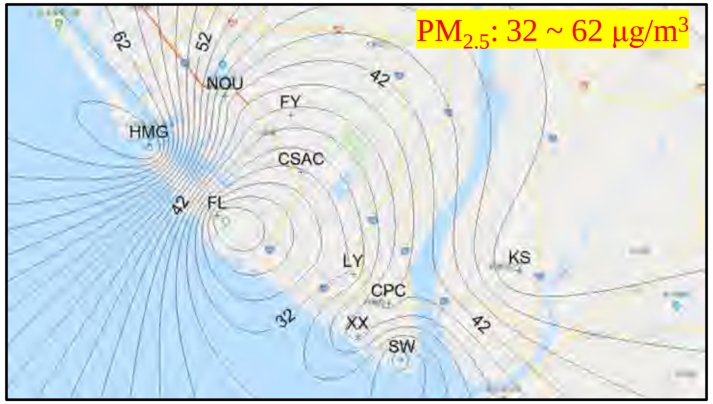
Introduction

- During winter and spring in Taiwan, northeasterly winds dominate the KaoPing Air Quality Zone (KPAQZ). During these seasons, pollutants do not disperse easily, resulting in worsened air quality.

Winter



Spring



- Because of the unique geographical location and meteorological conditions, it has been demonstrated that the environmental quality of Taiwan can be influenced by East Asian atmospheric pollution events, such as acid deposition, dust storm, and biomass burning (Sheu et al., 2010; Yang et al., 2012).

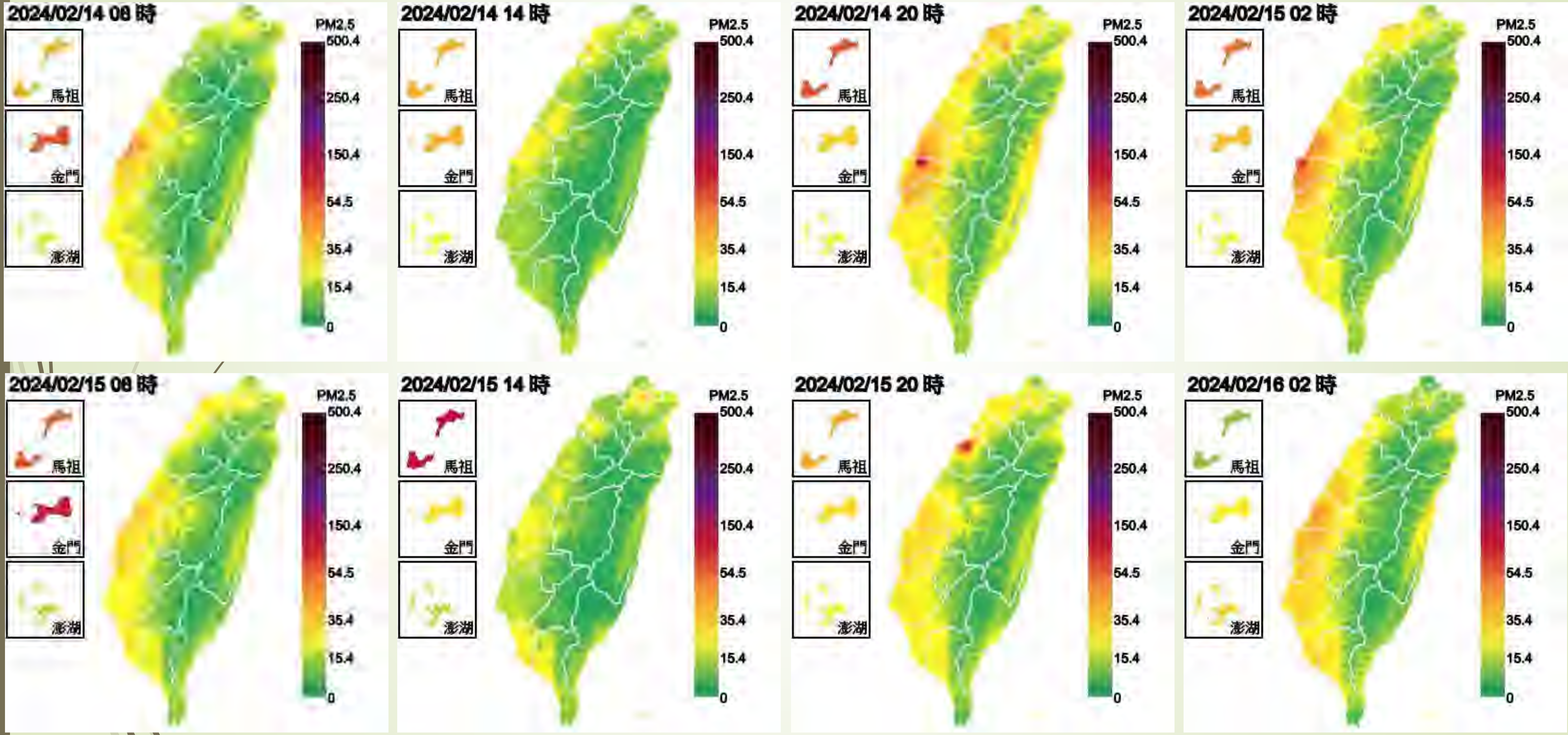
Chemical composition of ambient aerosols in KPEx 2024

- Four Intensive Observation Periods (IOPs) surrounding Kaohsiung and Pintung regions have been conducted, named as **KPEx 2024.**
- Four Intensive Observation Periods (IOPs) in 2024: Feb. 14–16 (IOP-1); Feb. 27–29 (IOP-2); March 12–13 (IOP-3); March 26-27 (IOP-4).
- Ambient $PM_{2.5}$ collected and chemical composition of aerosols measured: cations, anions, carboxylates, anhydrosugars, metals and carbons…..
- Explore the chemical fingerprints, spatiotemporal variation, and source apportionment of $PM_{2.5}$.

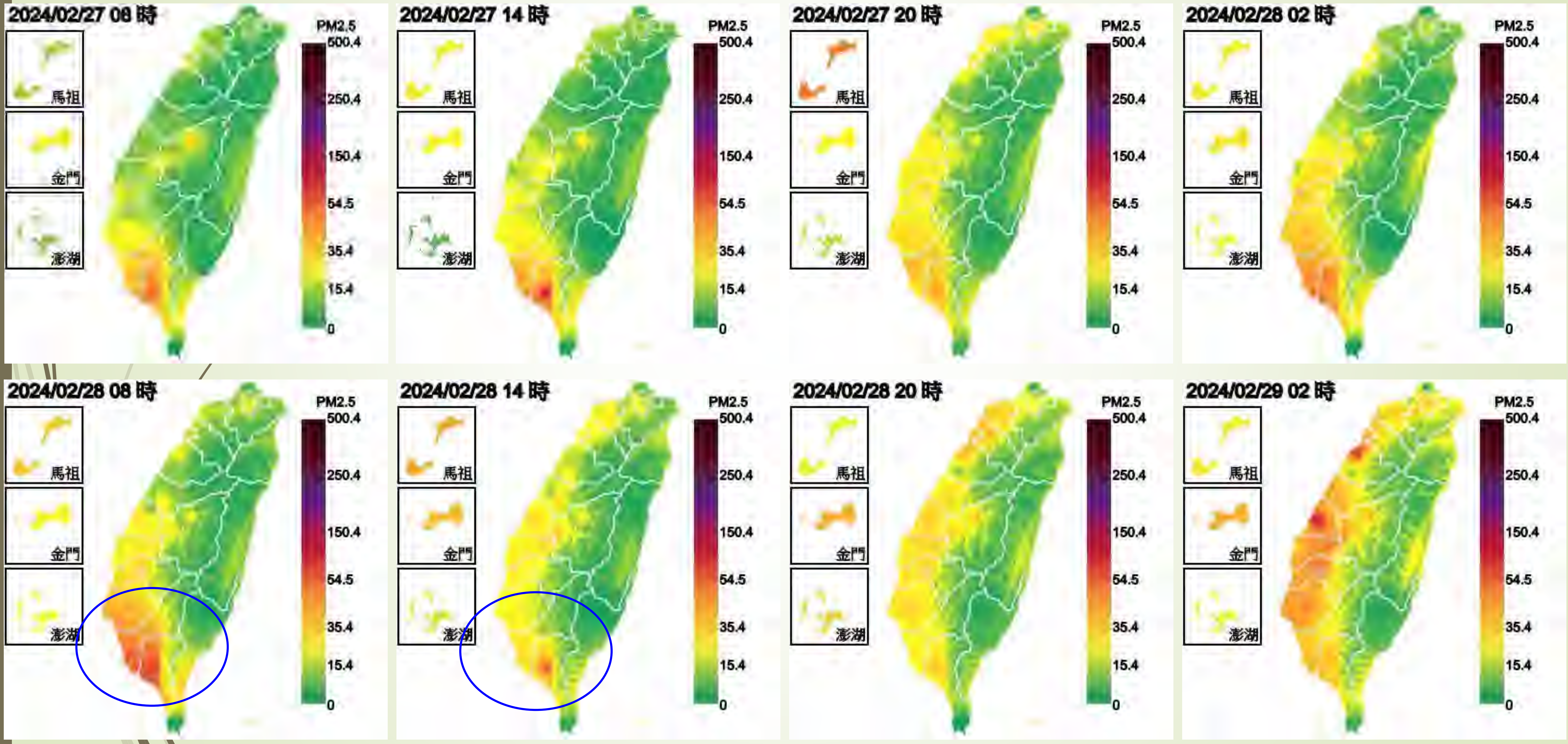
Description of sampling sites in KPEx 2024

Nanzi (urban/industrial), Fengshan (urban/traffic site), **Xiaogang** (urban/industrial), Sizihwan (**NSYSU**, urban, coastal), Neipu (**NPUST**, inland/background), **Xiao Liuqiu island** (background, surrounded by the sea) and **Fangshan** (background, seashore)

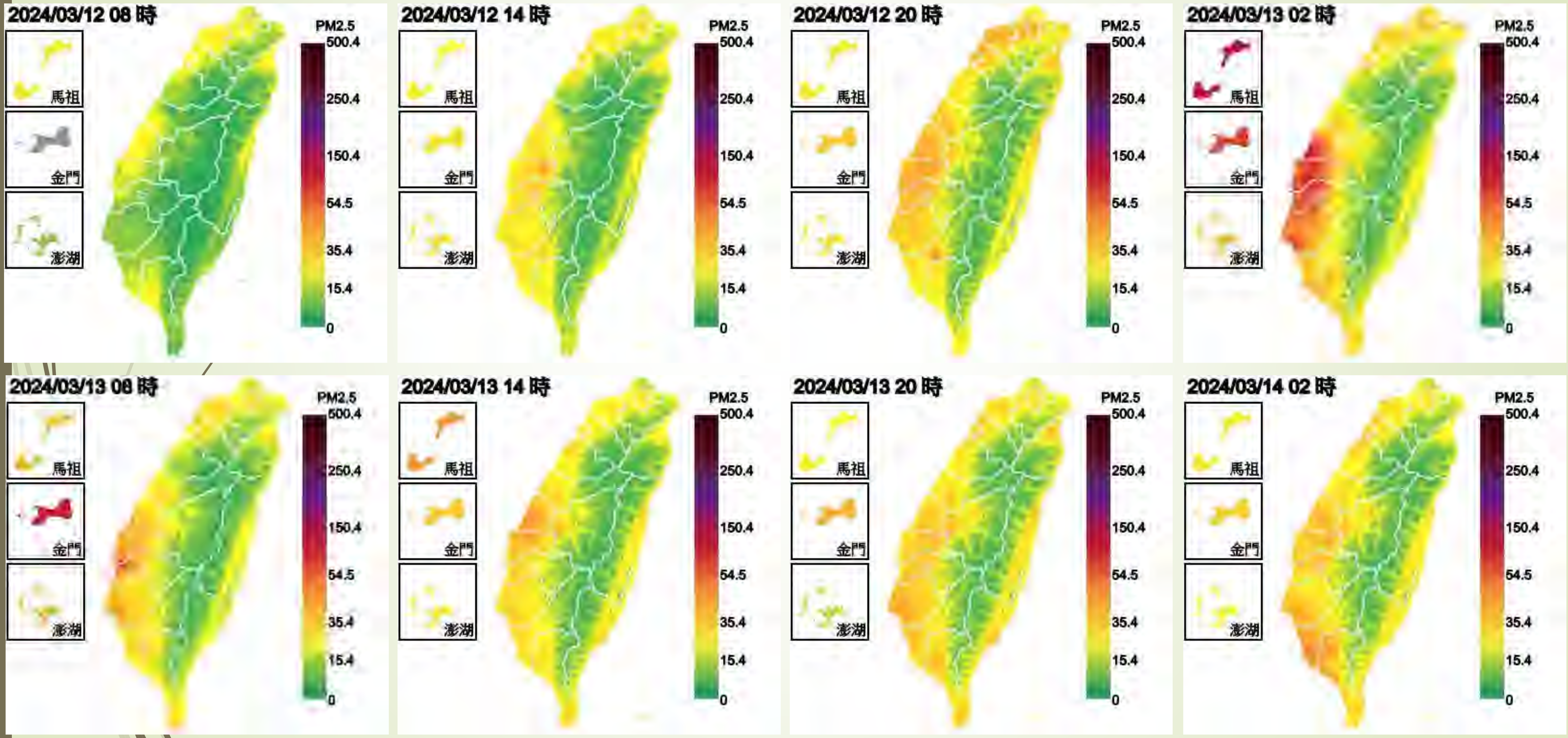
IOP 1: On Feb. 14-16, Higher concentrations were observed in the coastal areas of Changhua, Yunlin, and Chiayi compared to other regions in Taiwan.



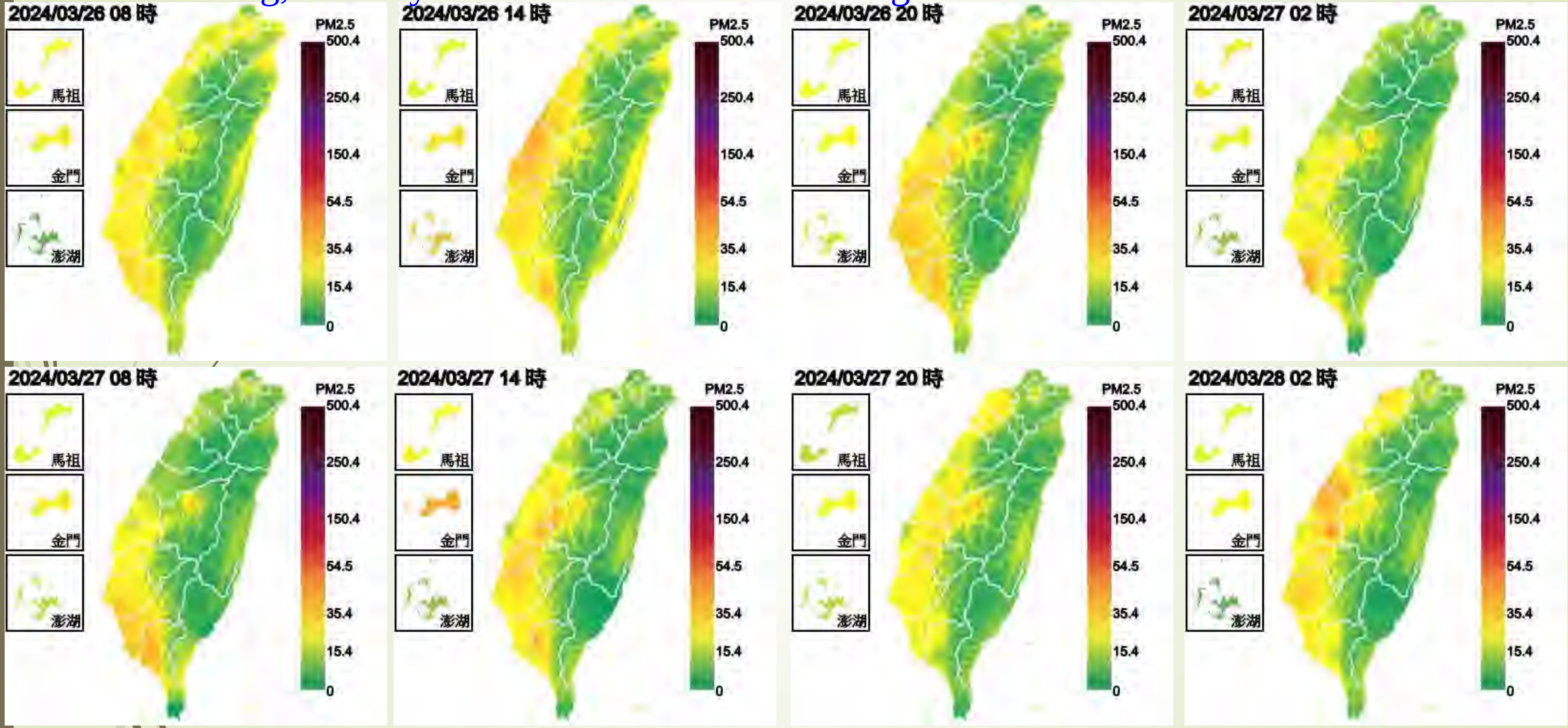
IOP 2: On Feb. 27, elevated concentrations were observed in the Kaoping region. On Feb. 28, concentrations began to increase across western Taiwan, whereas the Kaoping region experienced an increase in the morning followed by a decline in the afternoon..



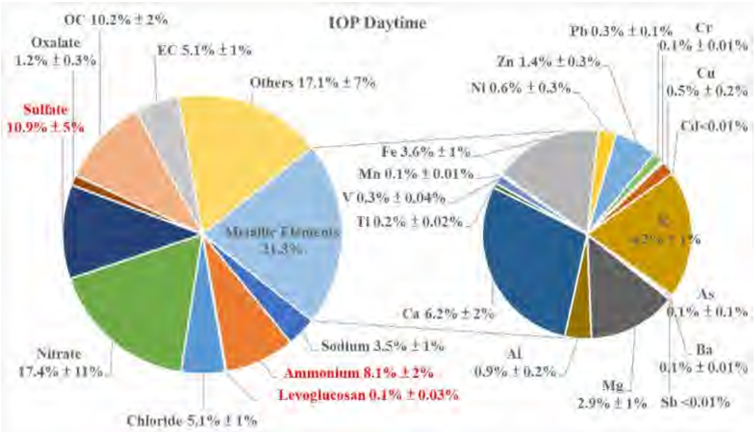
IOP 3: On March 12, slightly elevated concentrations were observed in the central and northern regions, and higher concentrations began to appear in other parts of Taiwan in the afternoon. On March 13, concentrations across western Taiwan started to increase.



IOP 4: On March 26, high concentrations shifted from the central region to the southern region. On March 27, elevated concentrations were observed in the Kaoping region during the morning, but they shifted back to the central region in the afternoon.

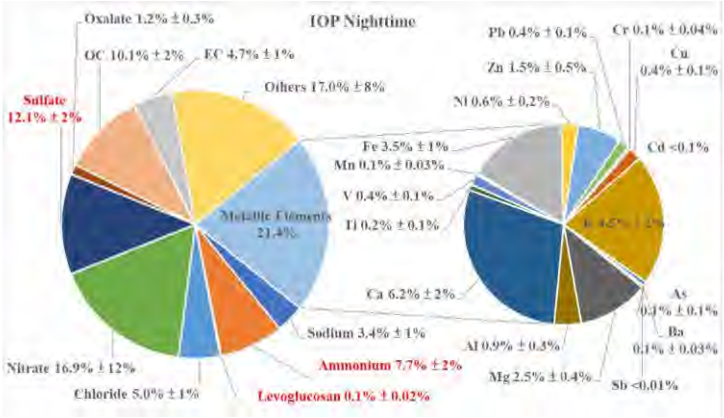


NSYSU (Urban, coastal)



$NO_3^- > SO_4^{2-} > NH_4^+$

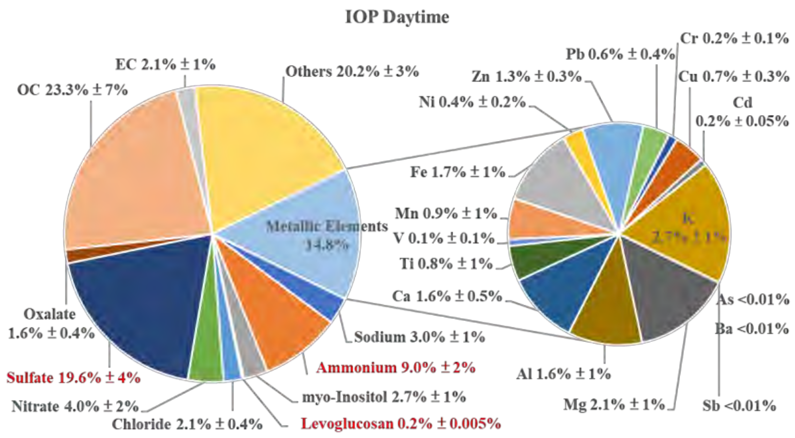
$PM_{2.5}$ mass conc. : 21.65 ± 4.09 μg/m³



$NO_3^- > SO_4^{2-} > NH_4^+$

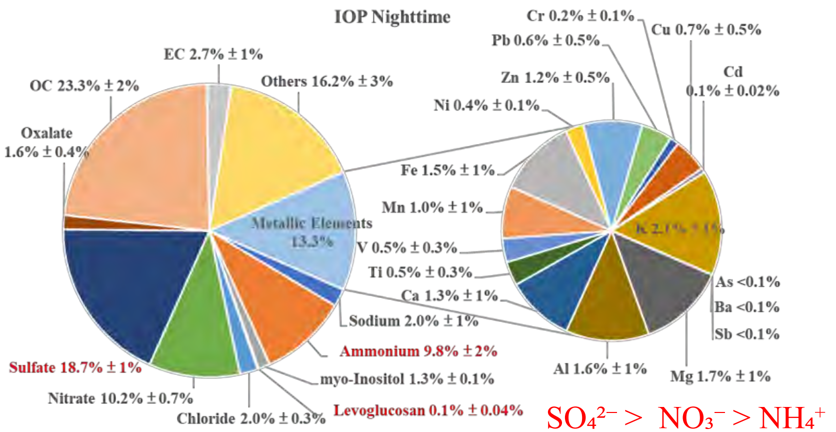
$PM_{2.5}$ mass conc. : 24.56 ± 5.68 μg/m³

Nanzi (Urban, industrial)



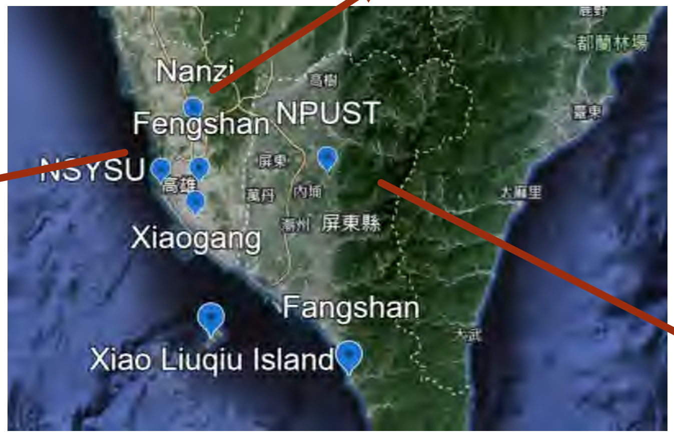
$PM_{2.5}$ mass conc. : 30.09 ± 3.26 μg/m³

$SO_4^{2-} > NH_4^+ > NO_3^-$

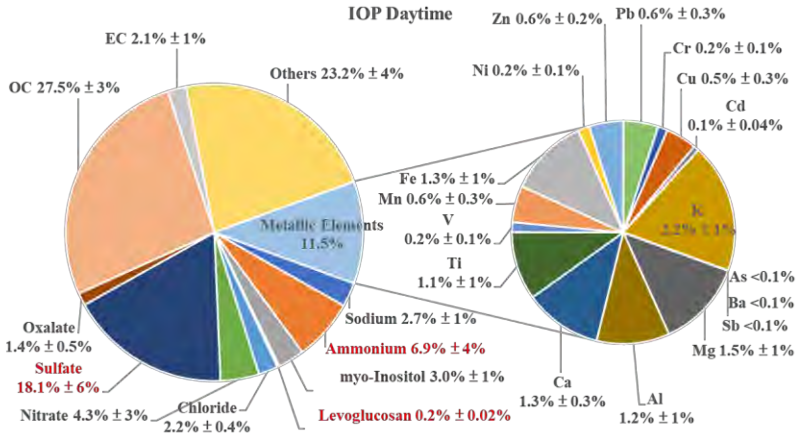


$SO_4^{2-} > NO_3^- > NH_4^+$

$PM_{2.5}$ mass conc. : 32.88 ± 4.43 μg/m³

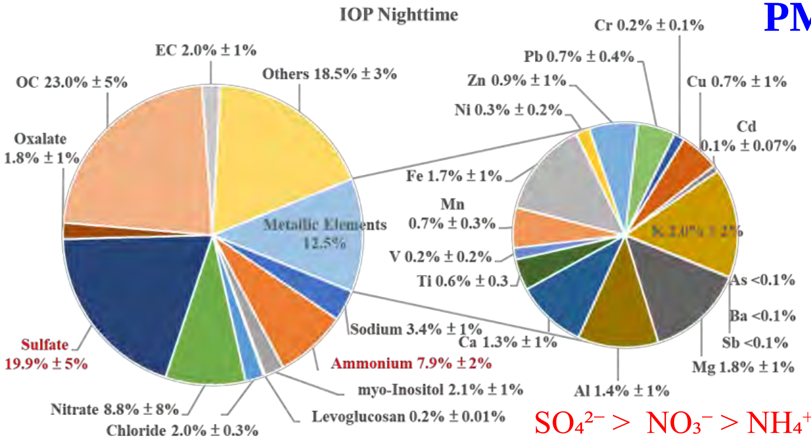


NPUST (Background, inland)



$SO_4^{2-} > NH_4^+ > NO_3^-$

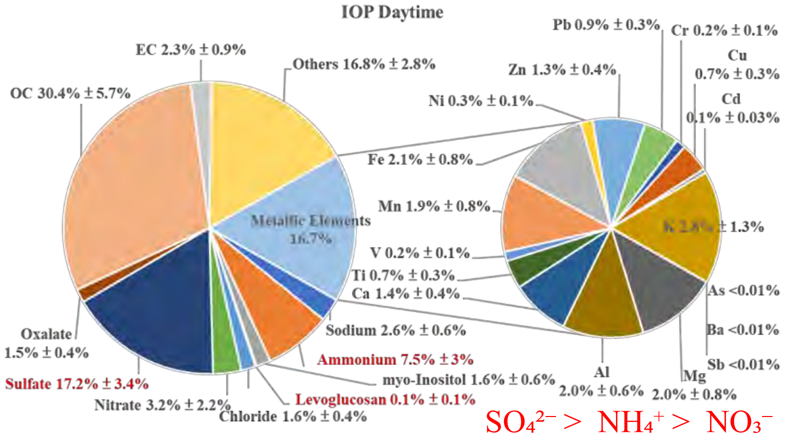
$PM_{2.5}$ mass conc.: 25.72 ± 3.23 μg/m³



$SO_4^{2-} > NO_3^- > NH_4^+$

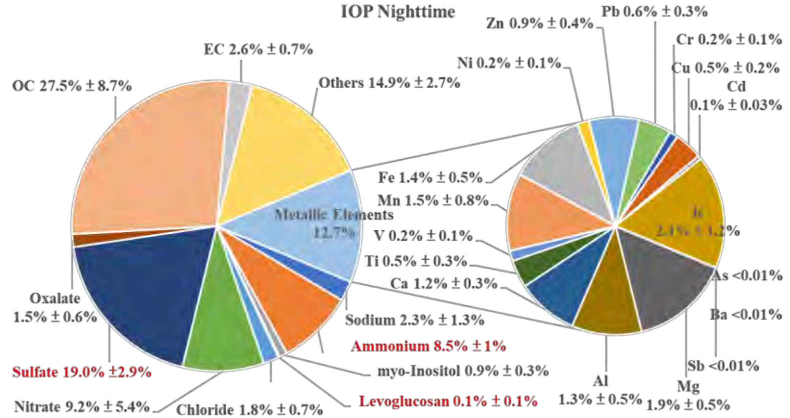
$PM_{2.5}$ mass conc.: 20.32 ± 3.8 μg/m³

Xiaogang
(Urban, industrial)



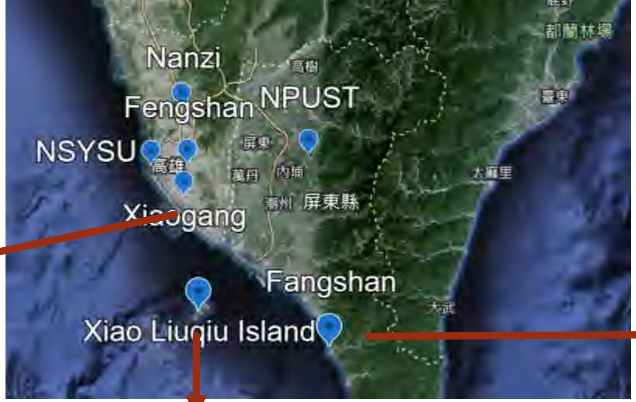
$SO_4^{2-} > NH_4^+ > NO_3^-$

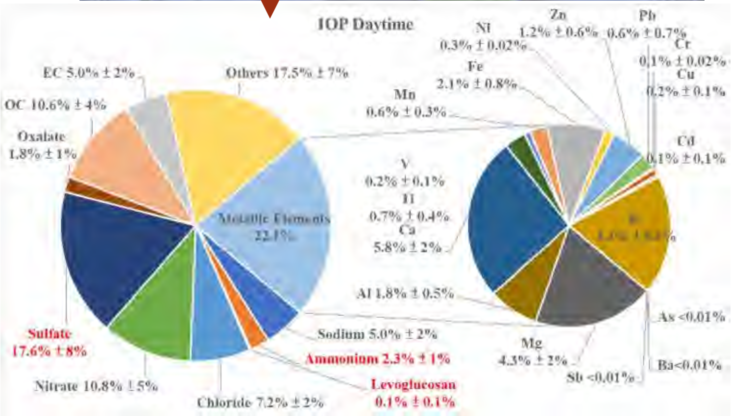
$PM_{2.5}$ mass conc.: 41.68 ± 5.2 μg/m^3



$SO_4^{2-} > NO_3^- > NH_4^+$

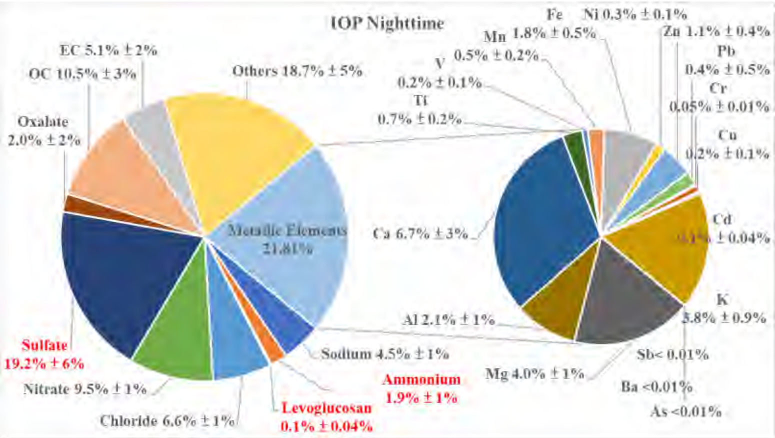
$PM_{2.5}$ mass conc.: 42.65 ± 7.36 μg/m^3





$SO_4^{2-} > NO_3^- > NH_4^+$

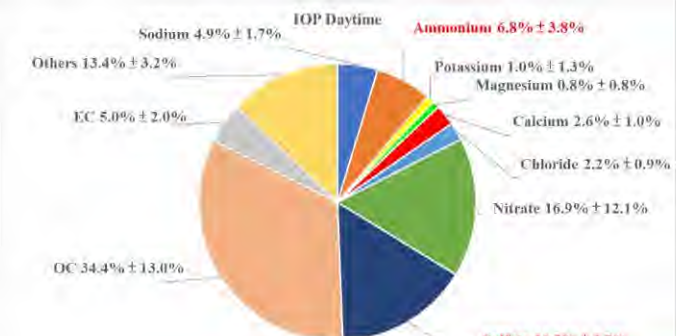
$PM_{2.5}$ mass conc.: 21.06 ± 8.62 μg/m^3



$PM_{2.5}$ mass conc.: 16.47 ± 4.35 μg/m^3 $SO_4^{2-} > NO_3^- > NH_4^+$

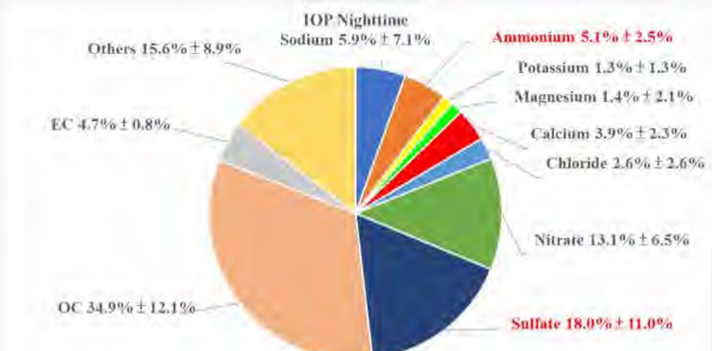
Xiaoliuqiu
(Background, surrounded by the sea)

Fangshan
(Background, seashore)



$NO_3^- > SO_4^{2-} > NH_4^+$

$PM_{2.5}$ mass conc.: 21.37 ± 6.83 μg/m^3

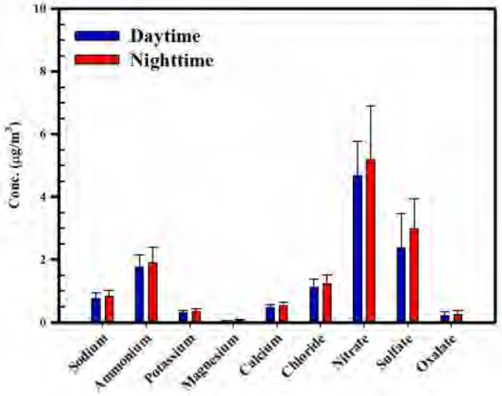


$SO_4^{2-} > NO_3^- > NH_4^+$

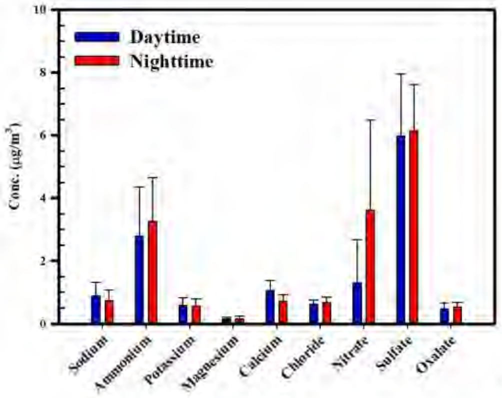
$PM_{2.5}$ mass conc.: 14.44 ± 6.12 μg/m^3

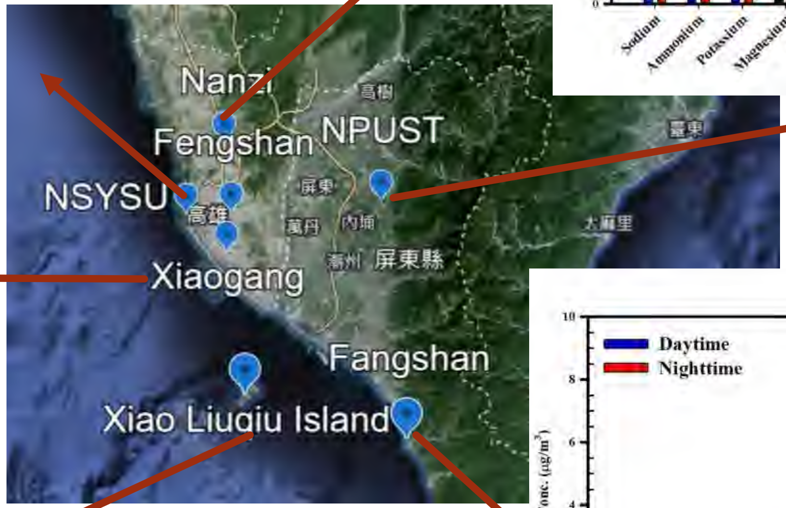
Daytime and nighttime conc. of $PM_{2.5}$ during IOPs in Feb. and March, 2024: Water-soluble ions and organic acids across urban, industrial, and background areas

NSYSU
(Urban, coastal)

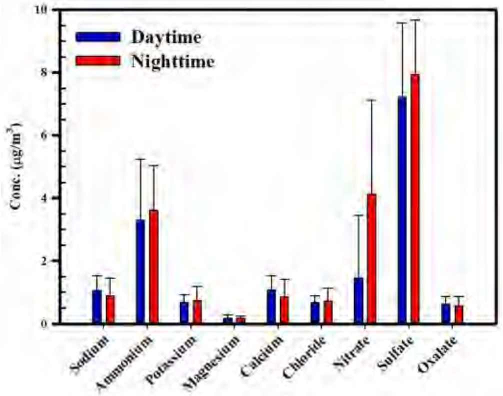


Nanzi
(Urban, industrial)

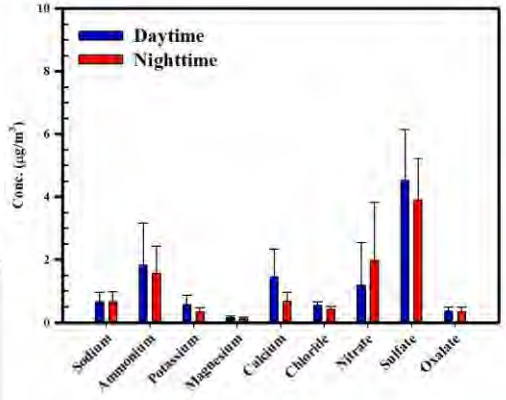




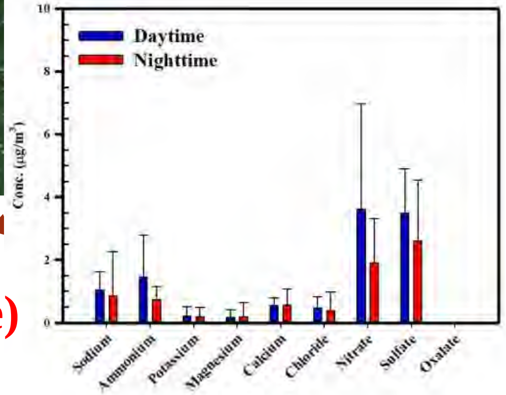
Xiaogang
(Urban, industrial)



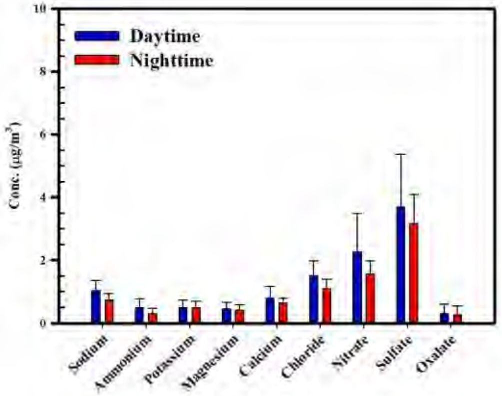
NPUST
(Background, inland)



Fangshan
(Background, seashore)



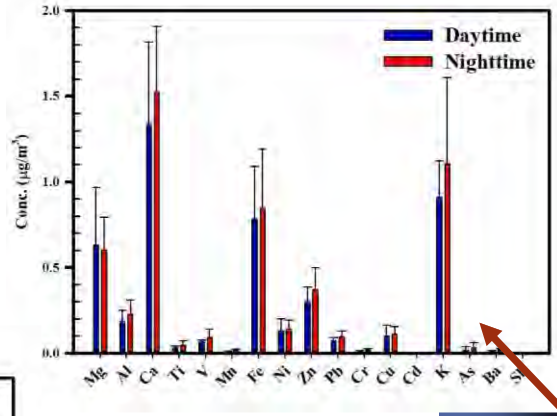
Xiaoliuqiu
(Background,
surrounded by the sea)



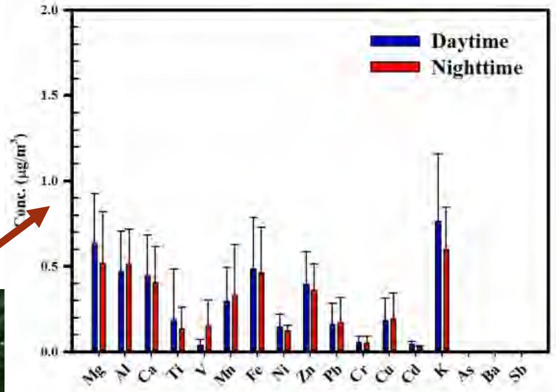
- At all locations, $PM_{2.5}$ composition is primarily dominated by ions such as SO_4^{2-}, NO_3^-, and NH_4^+, with SO_4^{2-} having the highest concentration with secondary inorganic aerosol contributions.
- Concentrations are consistently **highest** in the Xiaogang area and **lowest** in Xiaoliuqiu.
- **Oxalate** in photochemical aerosols are mainly derived from secondary organic aerosols (SOAs).

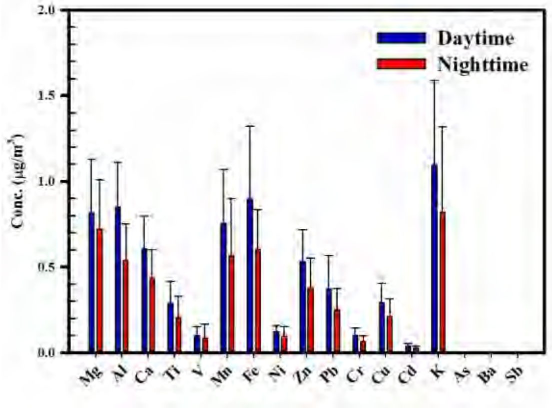
Daytime and nighttime conc. of $PM_{2.5}$ during IOPs in Feb. and March, 2024: Metals across urban, industrial, and background areas.

NSYSU
(Urban, coastal)

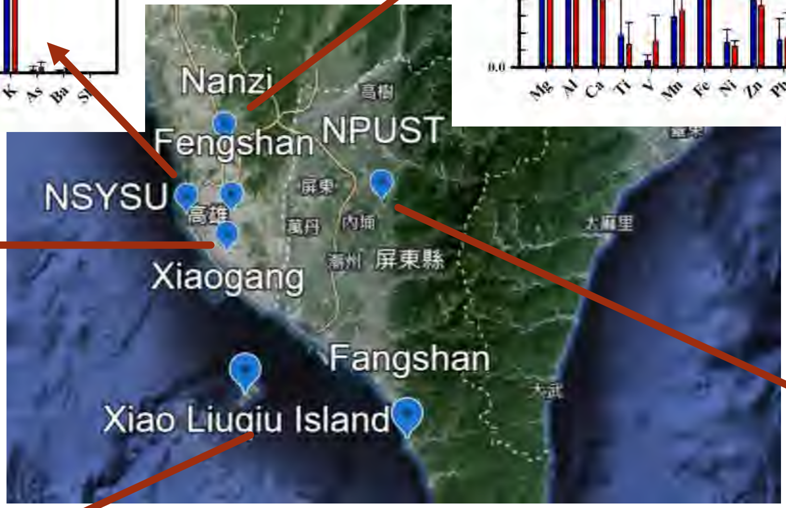


Nanzi
(Urban, industrial)

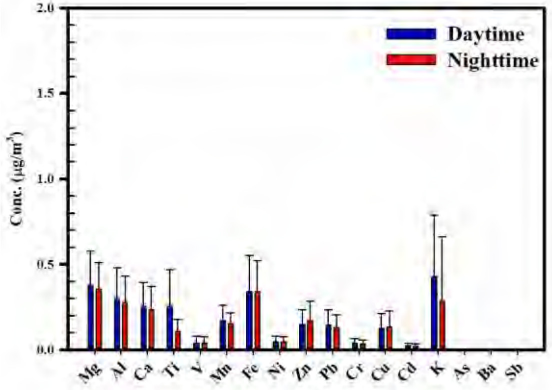




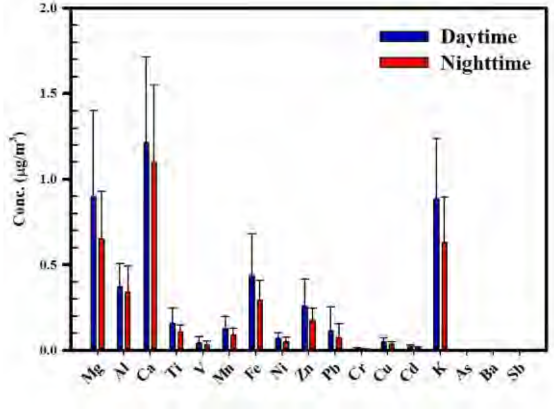
Xiaogang
(Urban, industrial)



NPUST
(Background, inland)



Xiaoliuqiu
(Background, surrounded by the sea)

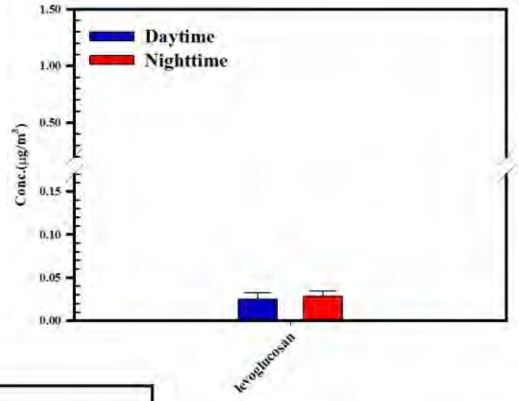


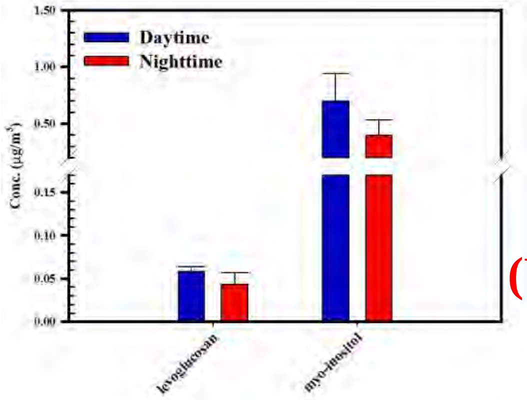
- Conc. of V, Mn, Ni, Zn, Pb, Cr, and Cu are consistently higher in urban and industrial areas than in background regions.
- Urban activities, including traffic and industrial emissions, make significant contributions to atmospheric $PM_{2.5}$, particularly in the Xiaogang area, where levels are associated with anthropogenic pollution sources and nearby metal industries.

Daytime and nighttime conc. of $PM_{2.5}$ during IOPs in Feb. and March, 2024: Inositol and Levoglucosan across urban, industrial, and background areas.

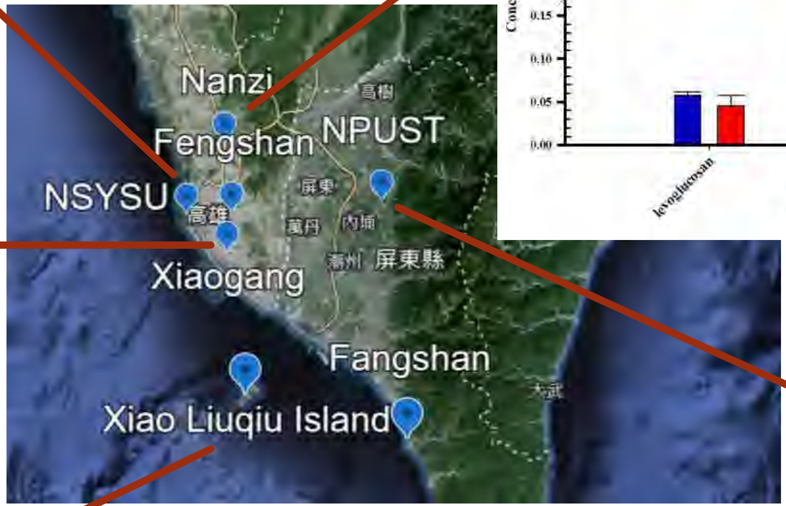
- Fungal metabolic emissions are higher during the day than at night, with inositol concentrations also elevated during daytime hours.

NSYSU (Urban, coastal)

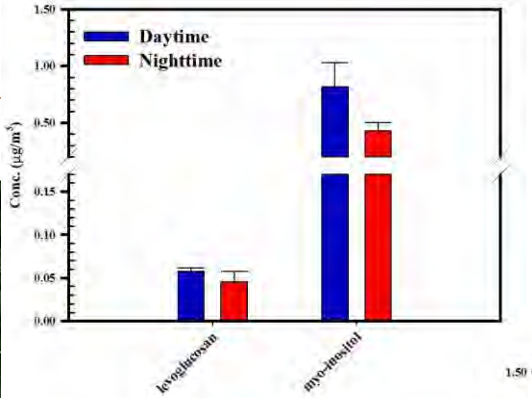




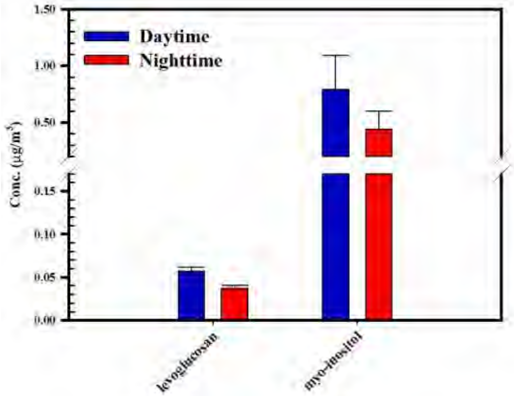
Xiaogang (Urban, industrial)



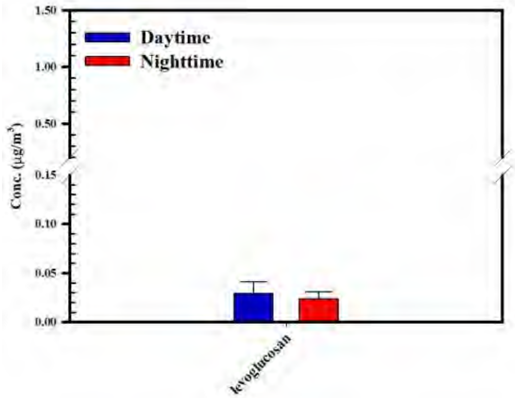
Nanzi (Urban, industrial)



NPUST (Background, inland)



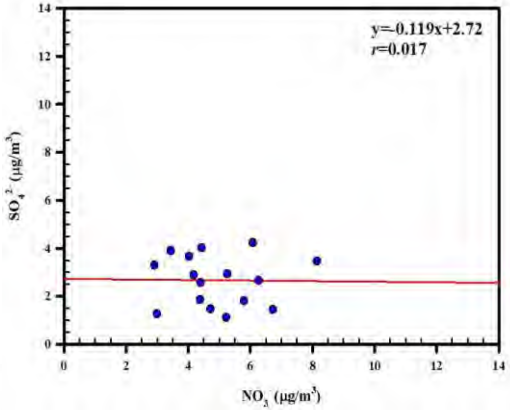
Xiaoliuqiu (Background, surrounded by the sea)

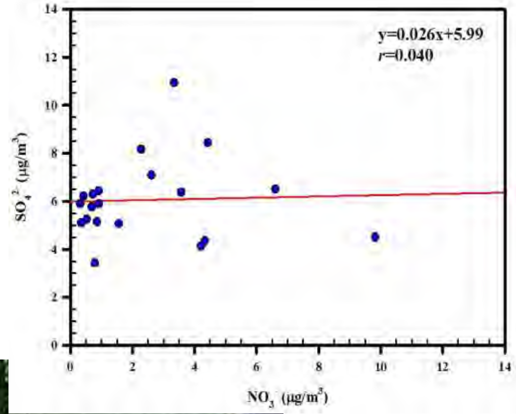


- The conc. of levoglucosan in coastal and inland background areas ranges from 20 to 80 ng/m³, with no consistent day-night concentration pattern observed; however, there is evidence of a continuous contribution from biomass burning in the environment.
- Levoglucosan levels are comparatively lower at the NSYSU and Xiaoliuqiu.

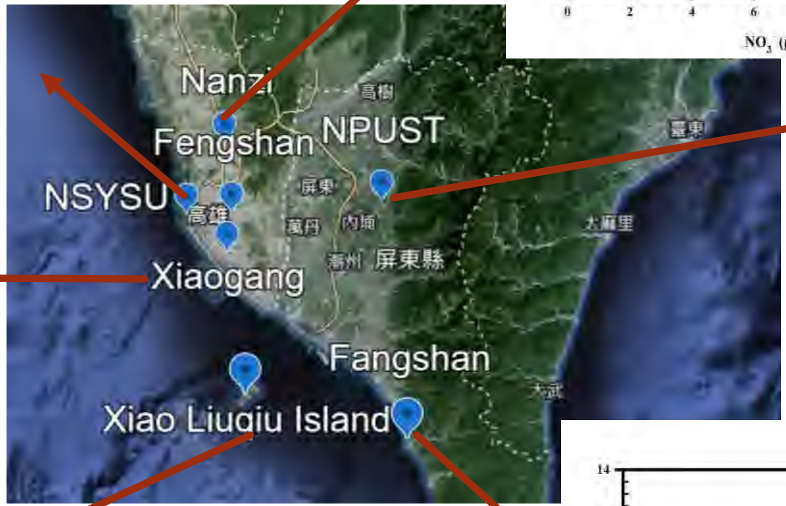
Relationship between sulfate and nitrate in $PM_{2.5}$

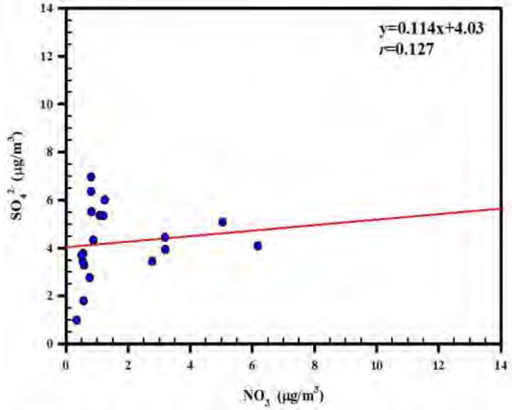
NSYSU
(Urban, coastal)

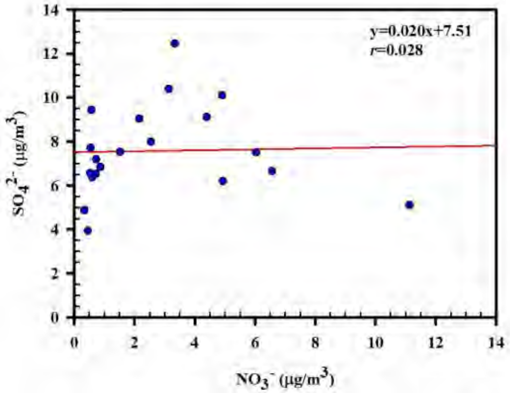




Nanzi
(Urban, industrial)



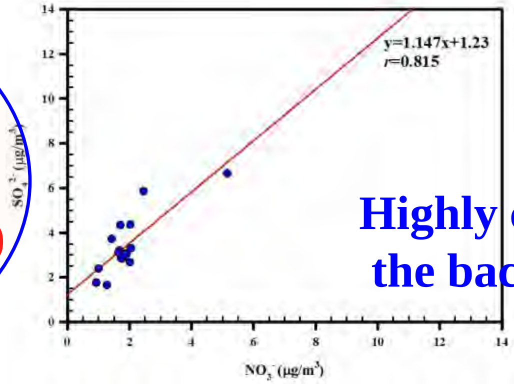




Xiaogang
(Urban, industrial)

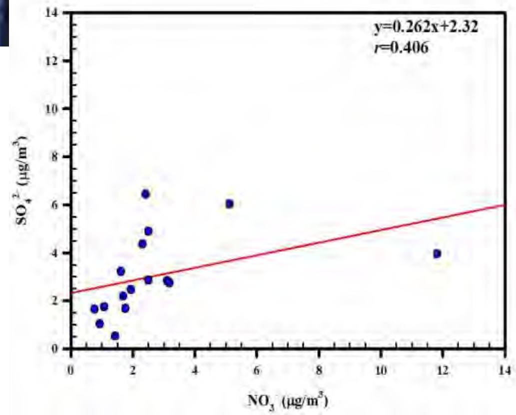
NPUST
(Background, inland)

Xiaoliuqiu
(Background,
surrounded by the sea)



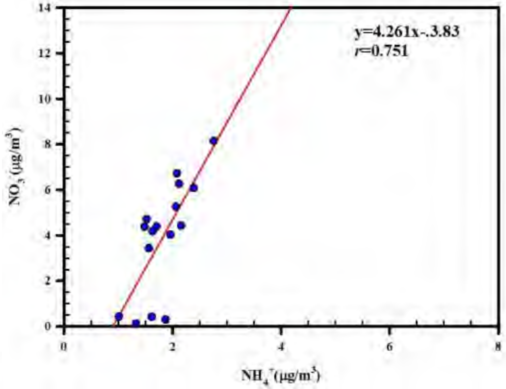
Fangshan
(Background, seashore)

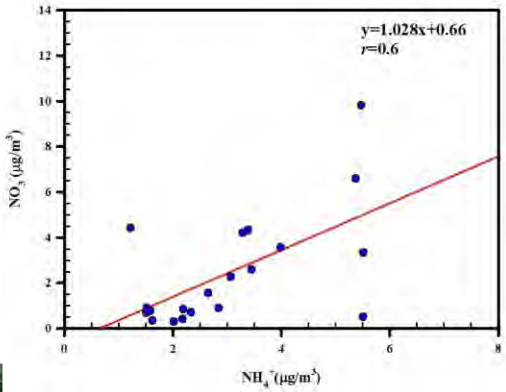
Highly correlation in
the background site



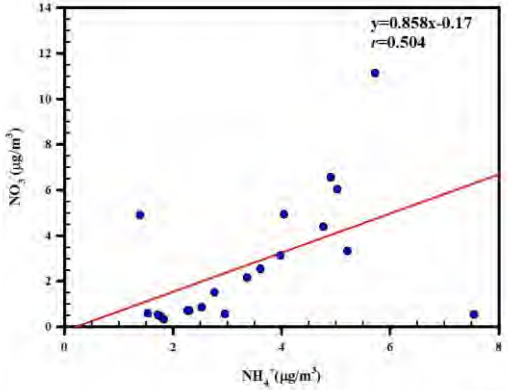
Relationship between ammonium and nitrate in $PM_{2.5}$

NSYSU
(Urban, coastal)

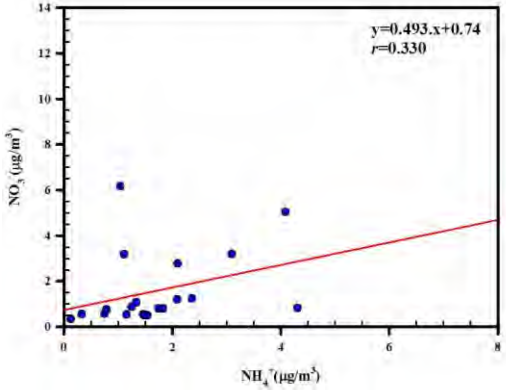




Nanzi
(Urban, industrial)

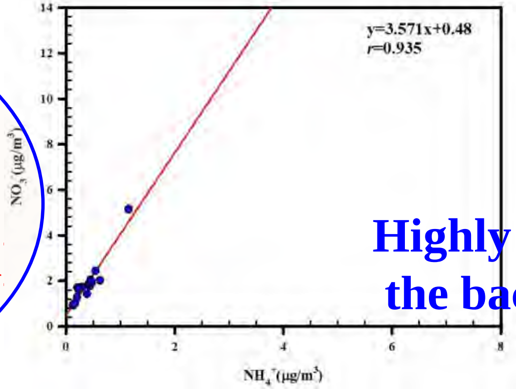


Xiaogang
(Urban, industrial)

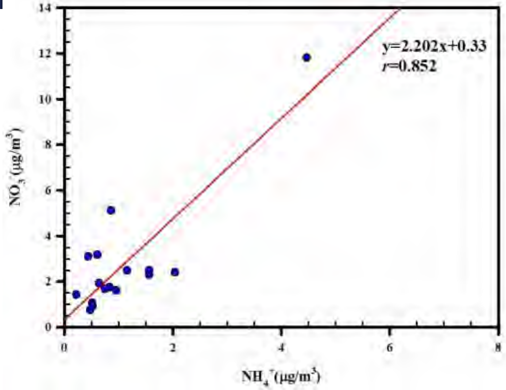


NPUST
(Background, inland)

Xiaoliuqiu
(Background,
surrounded by the sea



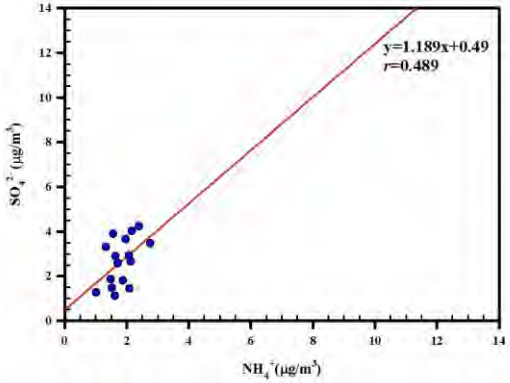
Fangshan
(Background, seashore)

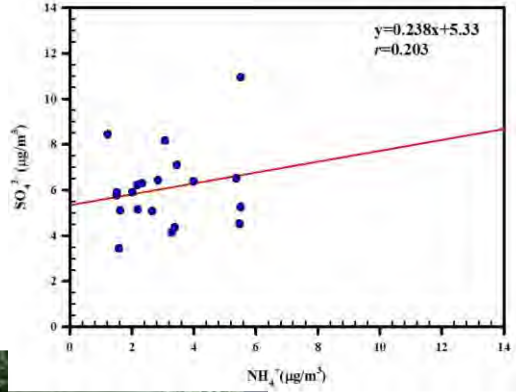


Highly correlation in the background site

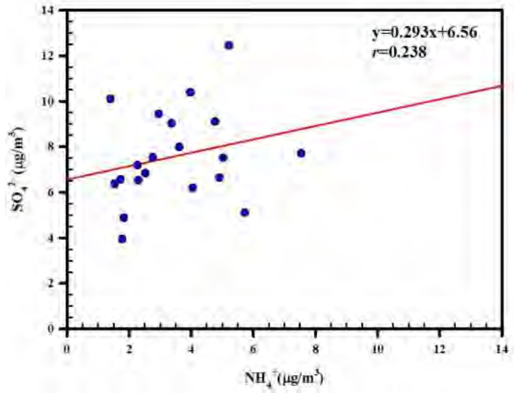
Relationship between sulfate and ammonium in $PM_{2.5}$

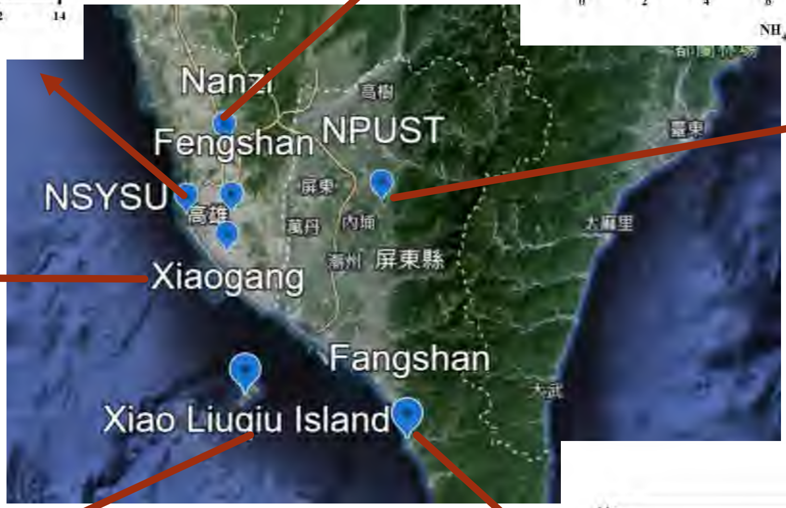
NSYSU
(Urban, coastal)

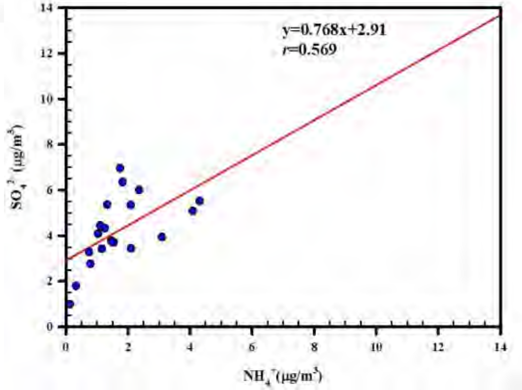




Nanzi
(Urban, industrial)



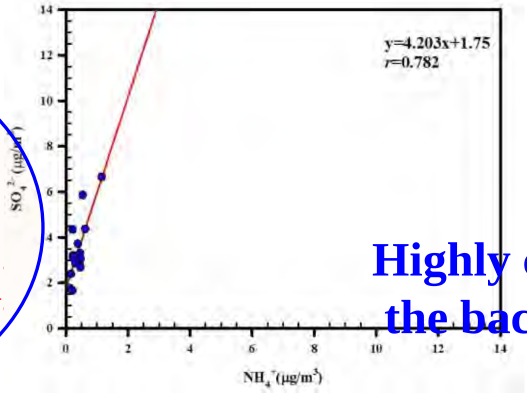




Xiaogang
(Urban, industrial)

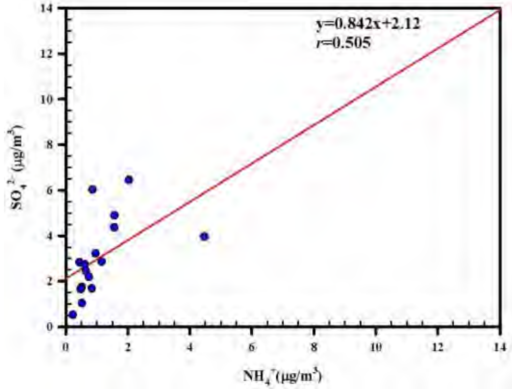
NPUST
(Background, inland)

Xiaoliuqiu
(Background, surrounded by the sea

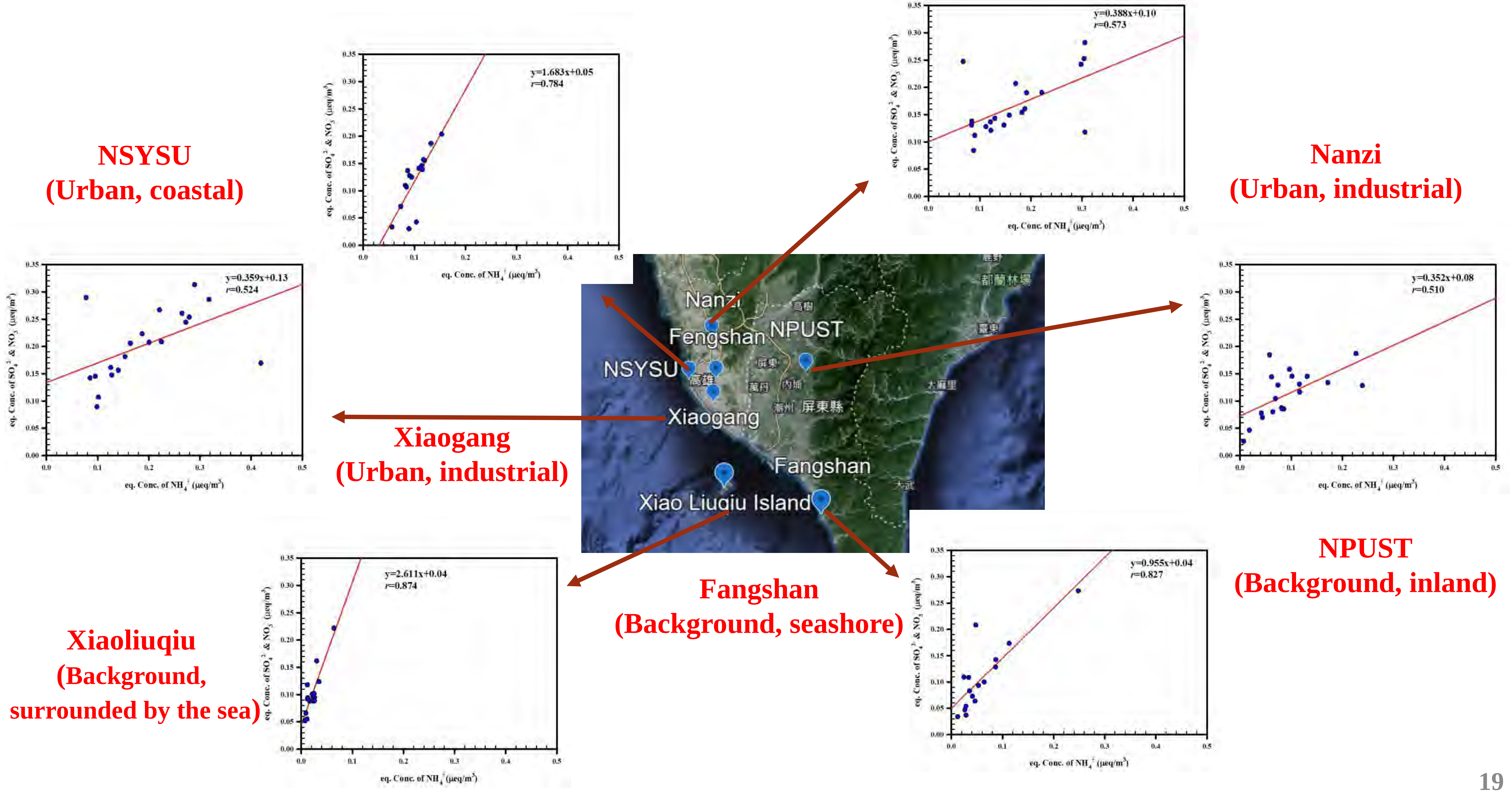


Fangshan
(Background, seashore)

Highly correlation in the background site

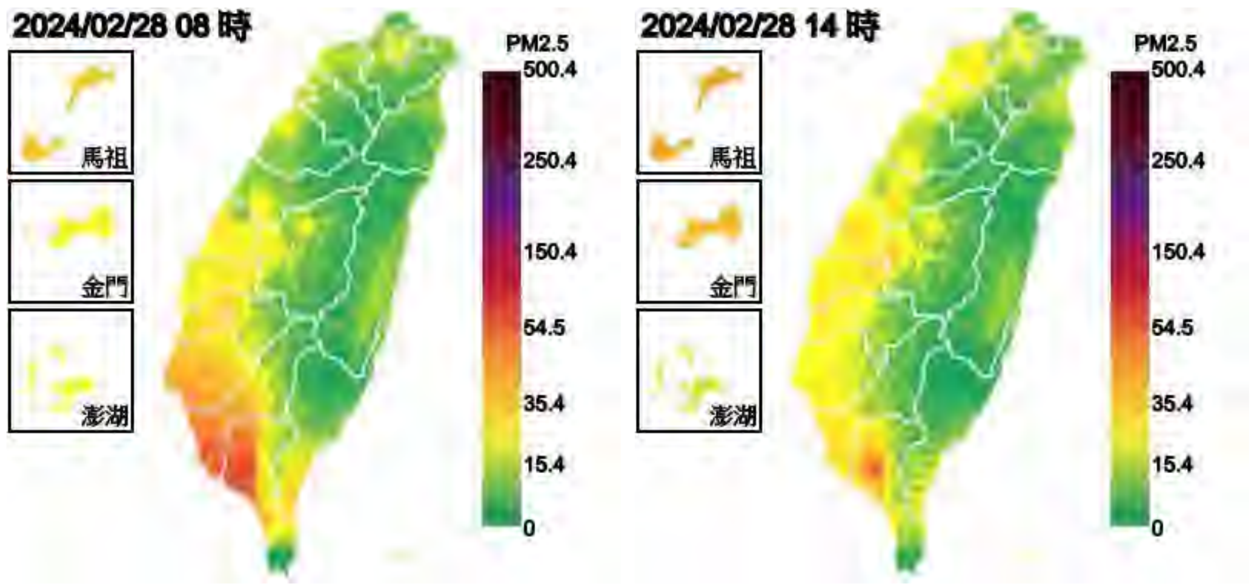


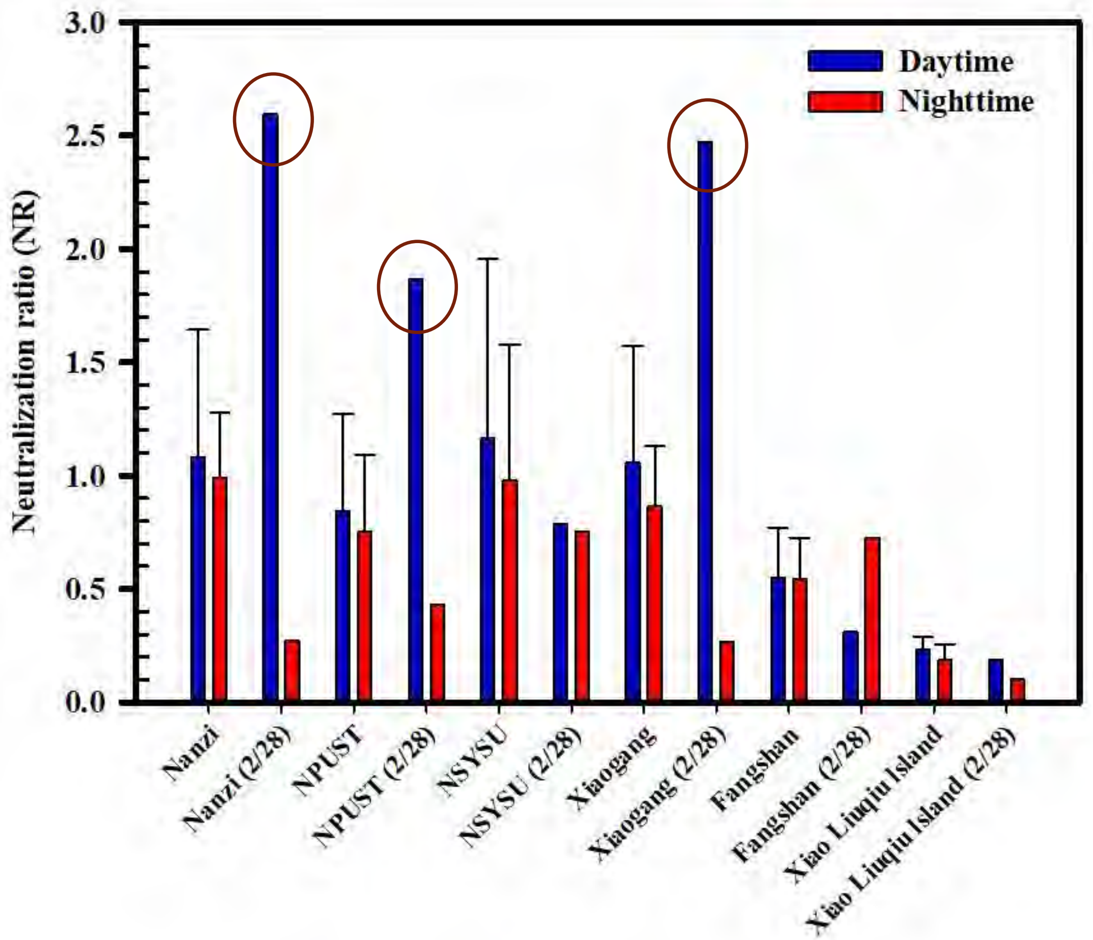
Relationship between eq. conc. of alkaline ions and acidic ions in $PM_{2.5}$



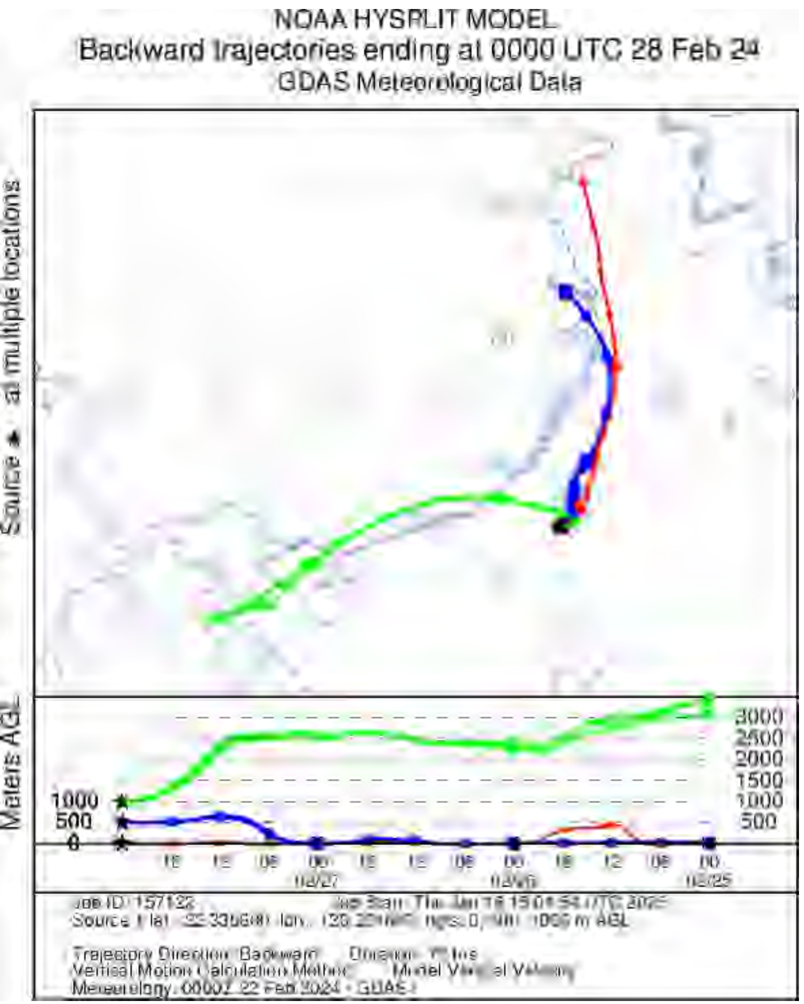
Neutralization ratio (NR)=

$$\frac{\text{equivalent conc. of } NH_4^+}{\text{equivalent conc. of } SO_4^{2-} + NO_3^-}$$

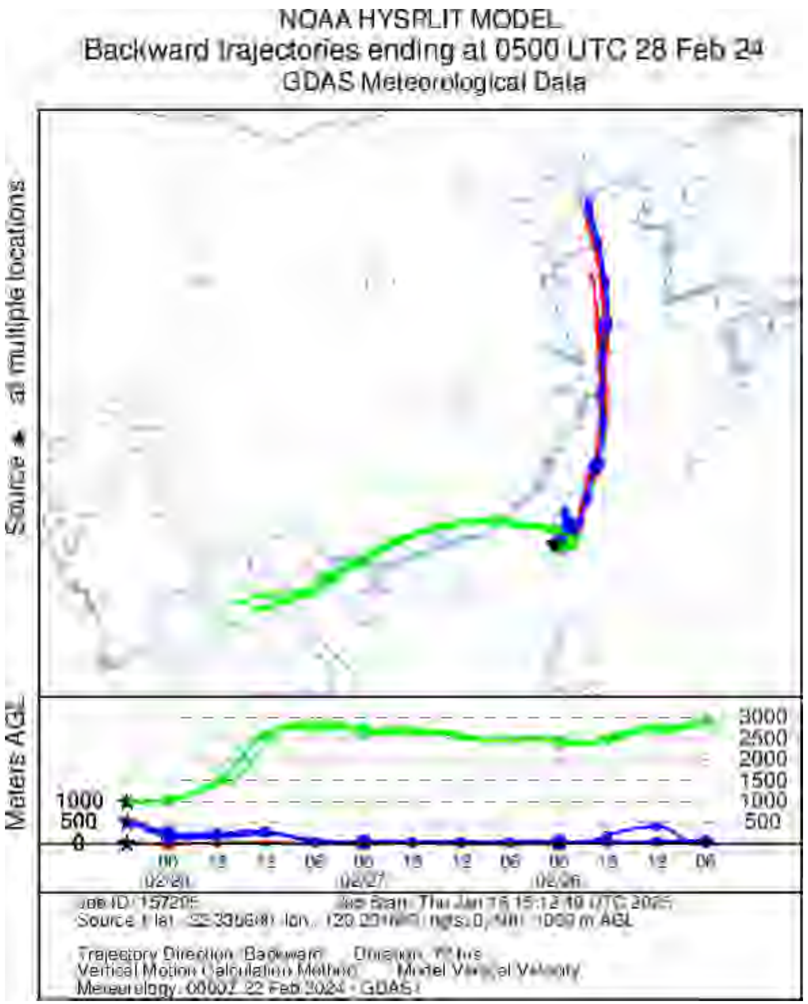




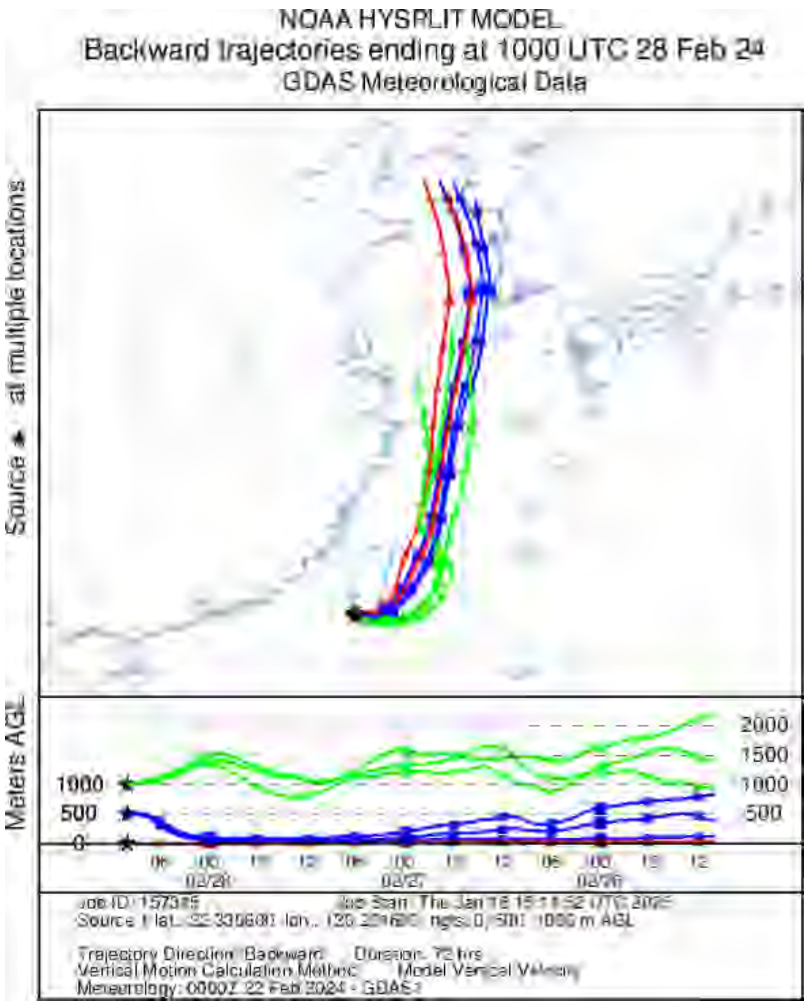
Daytime on February 28, 2024→episode



Taiwan time: 8 a.m. on Feb. 28



Taiwan time: 1 p.m. on Feb. 28

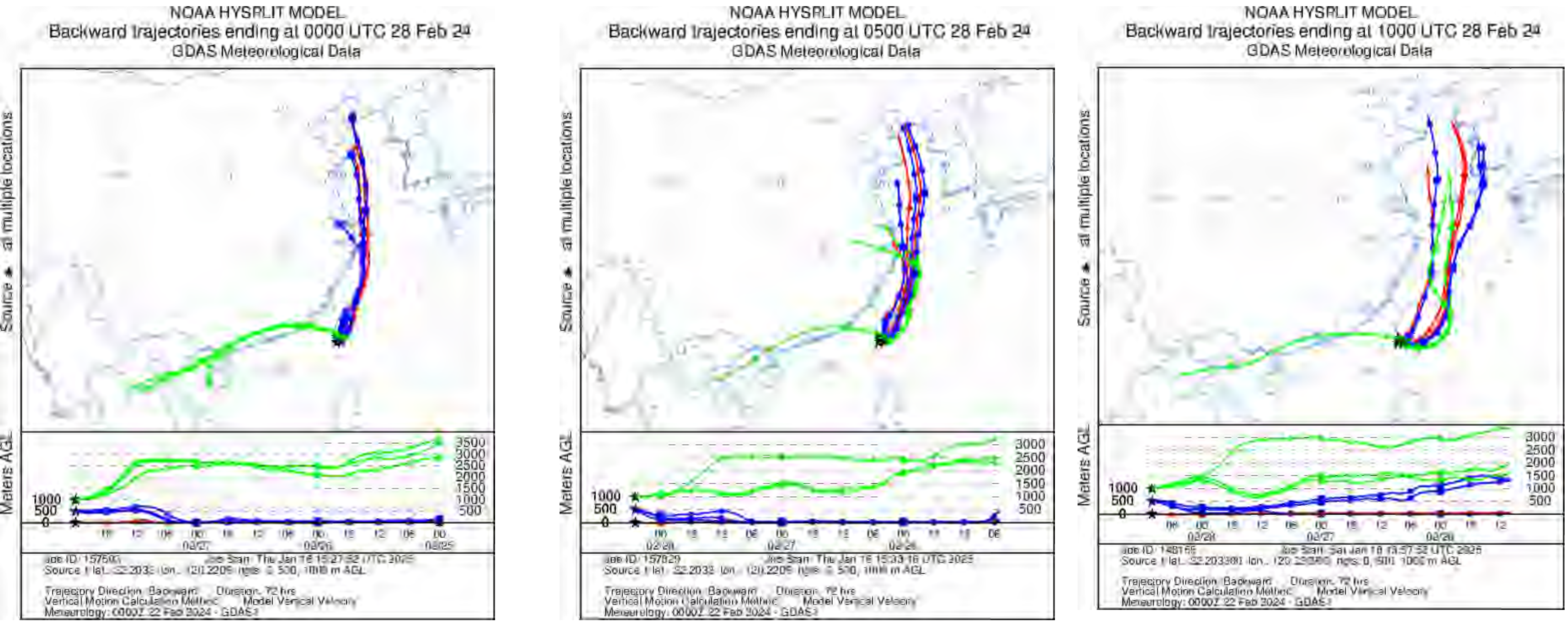


Taiwan time: 6 p.m. on Feb. 28

Xiaogang
(Urban, industrial)

NPUST
(Background, inland)

Nanzi
(Urban, industrial)



Taiwan time: 8 a.m. on Feb. 28

Taiwan time: 1 p.m. on Feb. 28

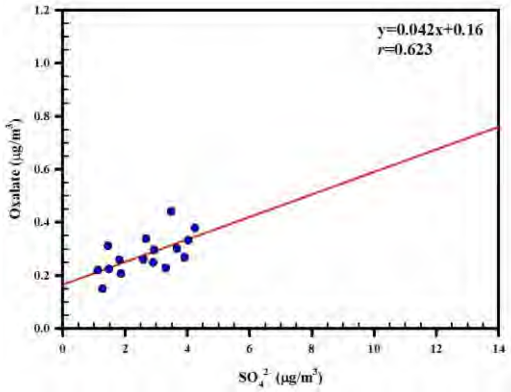
Taiwan time: 6 p.m. on Feb. 28

Xiaoliuqiu
(Background, surrounded by the sea)

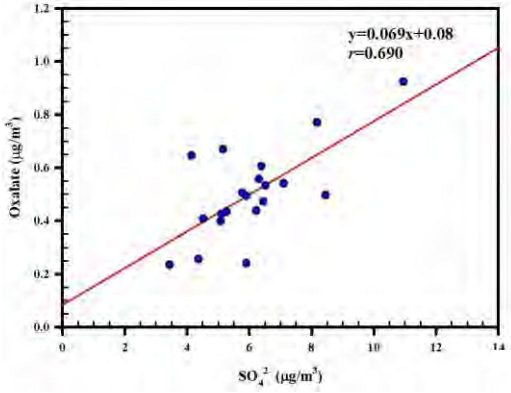
NSYSU
(Urban, coastal)

Fangshan
(Background, seashore)

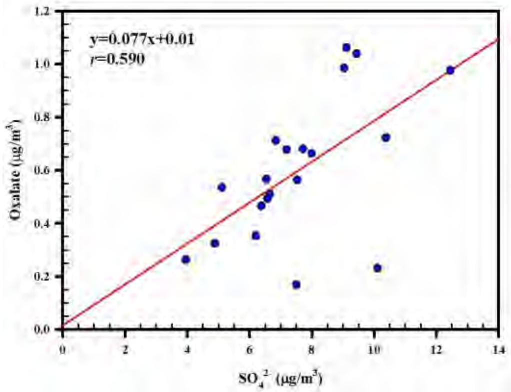
Relationship between sulfate and oxalate in $PM_{2.5}$

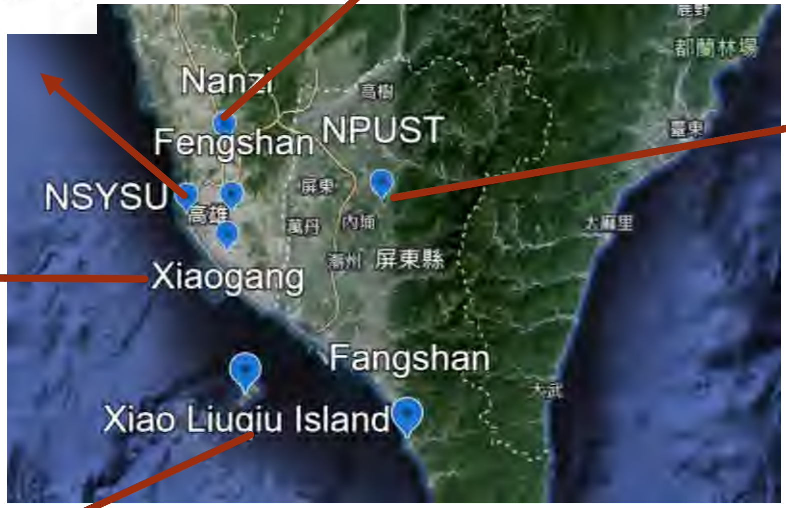


NSYSU
(Urban, coastal)

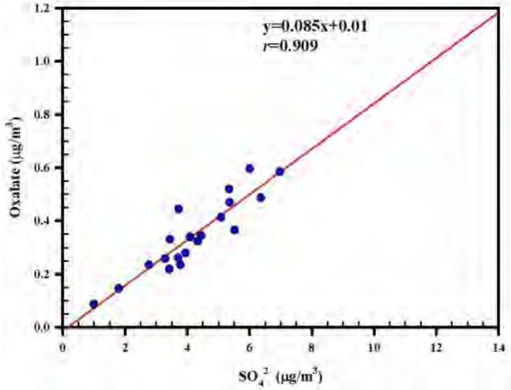


Nanzi
(Urban, industrial)

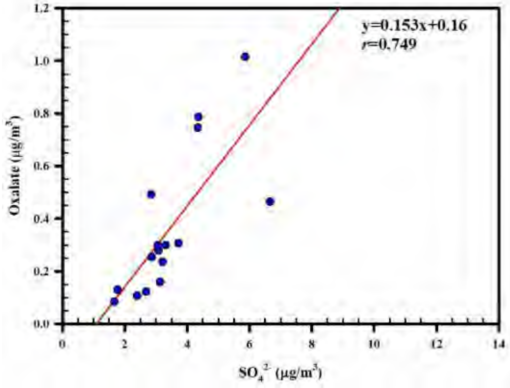




Xiaogang
(Urban, industrial)



NPUST
(Background, inland)

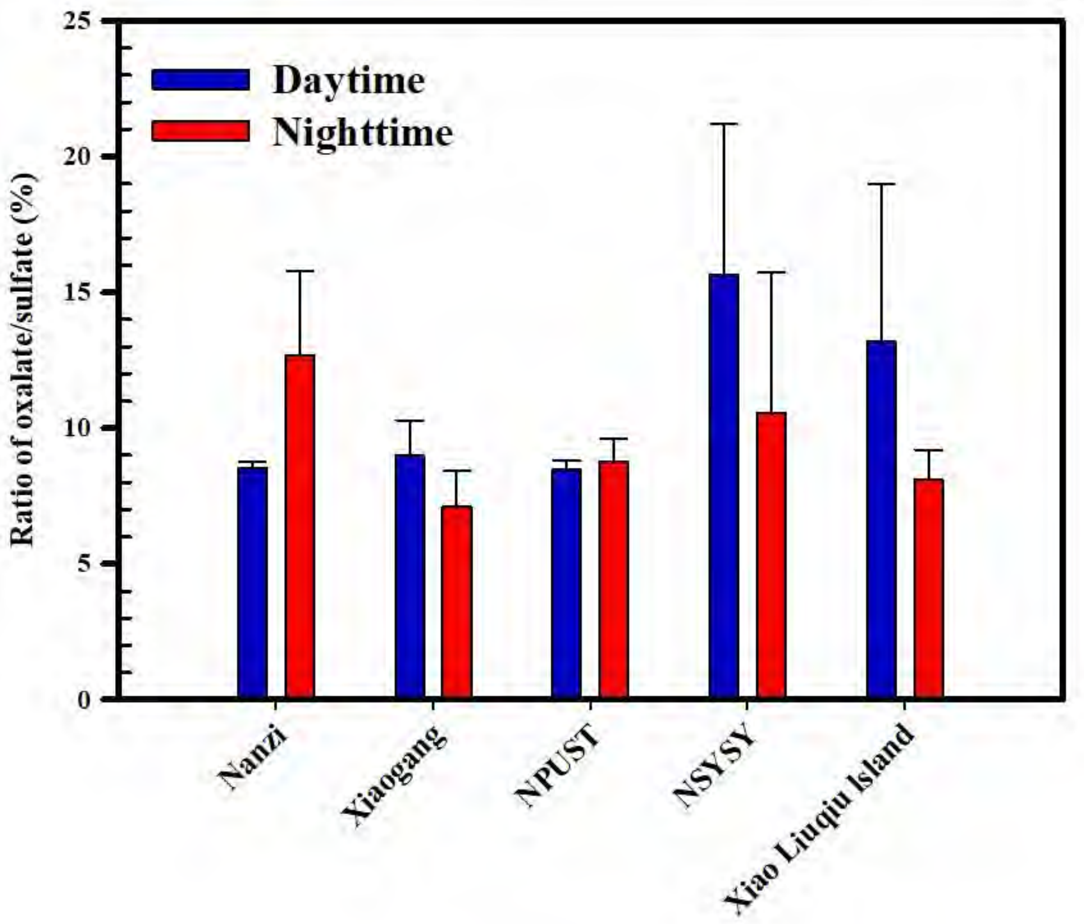


Xiaoliuqiu
(Background,
surrounded by the sea)

Photochemical final inorganic and organic products

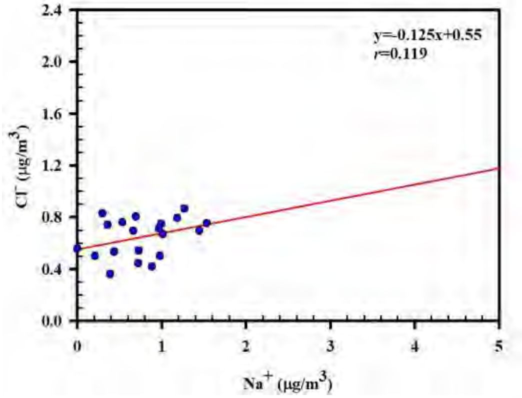
Oxalate/sulfate ratios of atmospheric $PM_{2.5}$

- The oxalate/sulfate ratios of atmospheric $PM_{2.5}$ range from 5.87% to 11.83%, with an average of 8.05%.
- In Xiaogang, NSYS and Xiaoliuqiu, the average O/S during the day is higher than that at night, indicating that there is more **organic** photochemical production potential during the day, especially in NSYS and Xiaoliuqiu, which are both near the sea. There is more organic photochemical potential during the day, while the O/S of Nanzi and NPUST are higher at night than during the day, which also shows that the inland environment has stronger inorganic photochemical potential during the day.

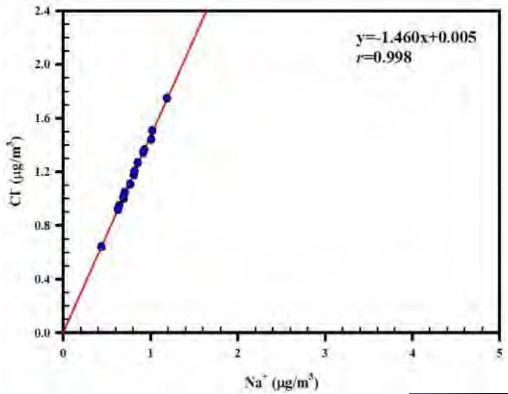


Oxalate/sulfate ratios of atmospheric $PM_{2.5}$

Relationship between sodium and chloride in $PM_{2.5}$

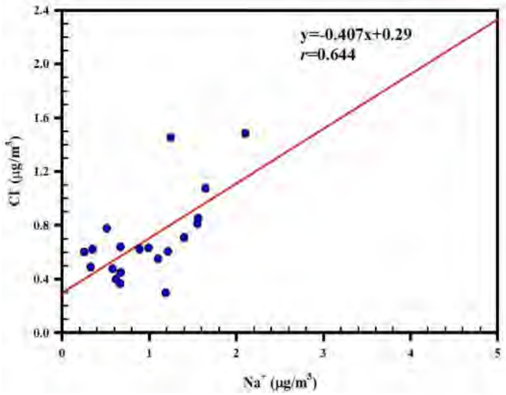


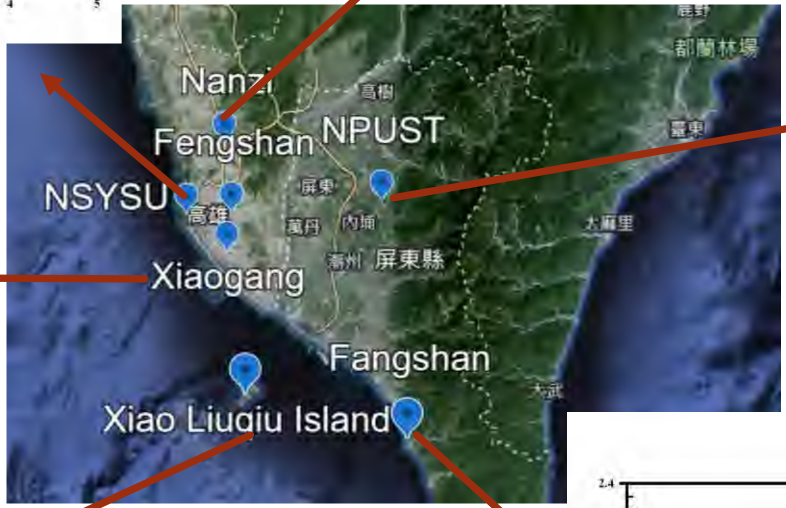
Sea spray

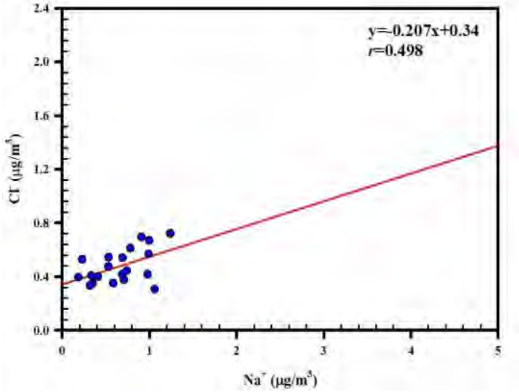


NSYSU
(Urban, coastal)

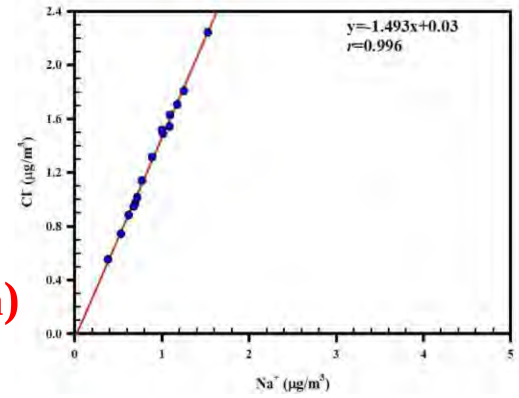
Nanzi
(Urban, industrial)



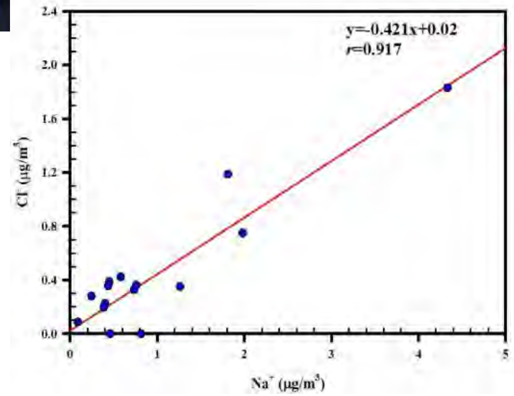




Xiaogang
(Urban, industrial)



Fangshan
(Background, seashore)



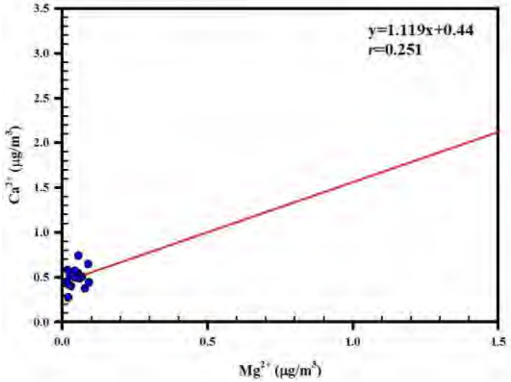
NPUST
(Background, inland)

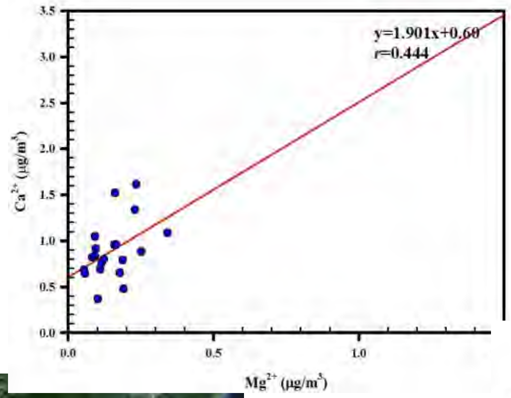
Xiaoliuqiu
(Background,
surrounded by the sea)

Relationship between Mg^{2+} and Ca^{2+} in $PM_{2.5}$

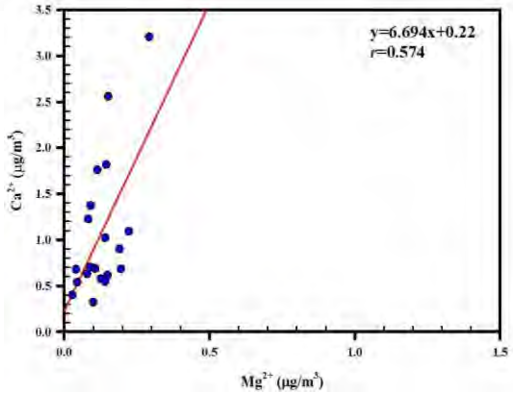
Crustal matters

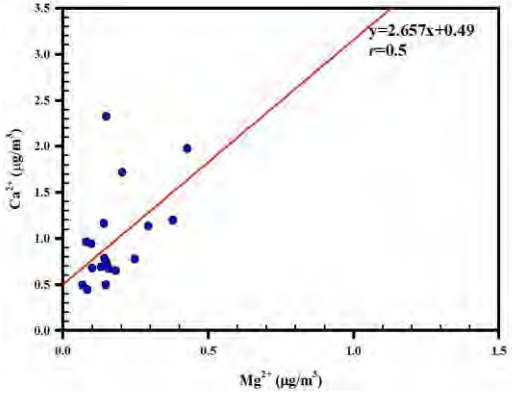
NSYSU
(Urban, coastal)





Nanzi
(Urban, industrial)

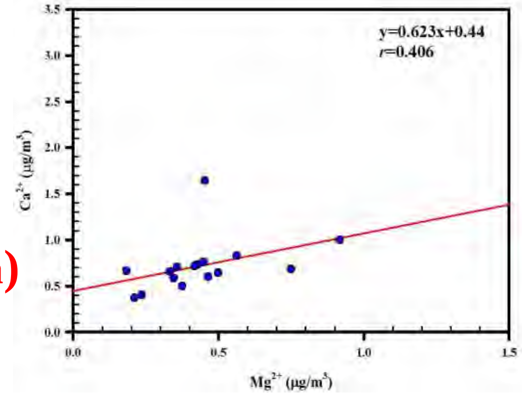




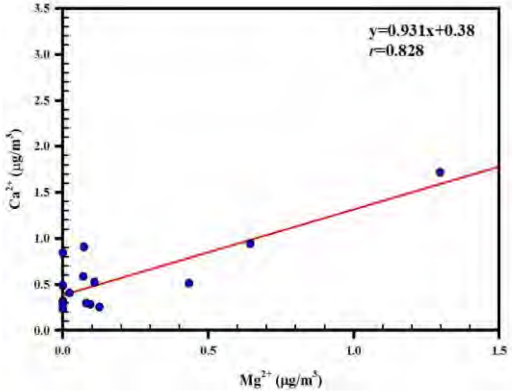
Xiaogang
(Urban, industrial)

NPUST
(Background, inland)

Fangshan
(Background, seashore)

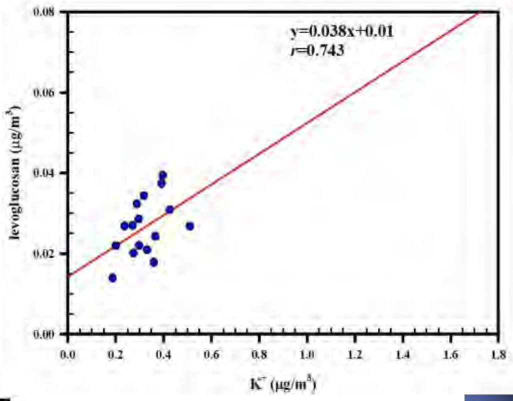


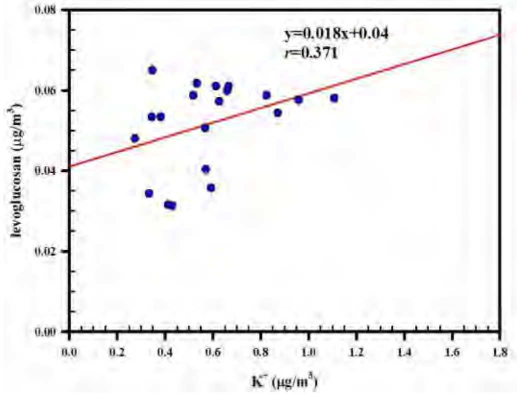
Xiaoliuqiu
(Background,
surrounded by the sea)



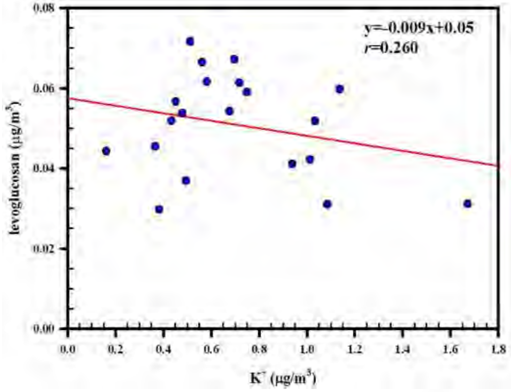
Relationship between K^+ and levoglucosan in $PM_{2.5}$

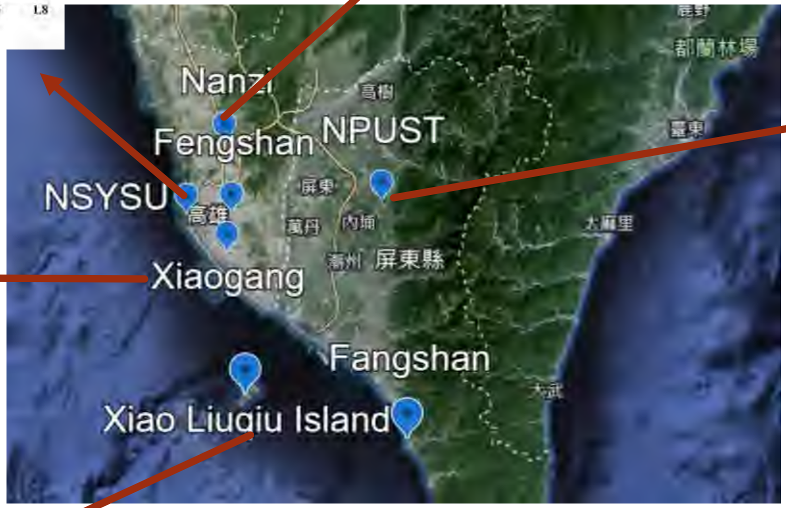
NSYSU
(Urban, coastal)



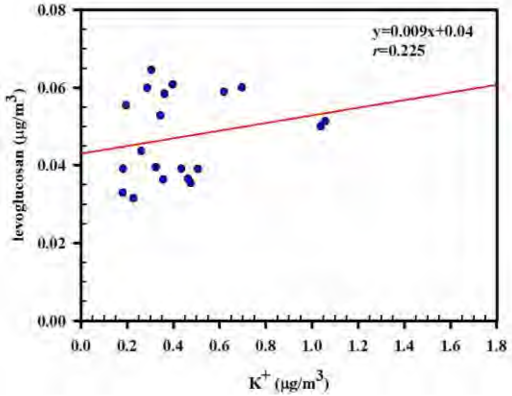


Nanzi
(Urban, industrial)



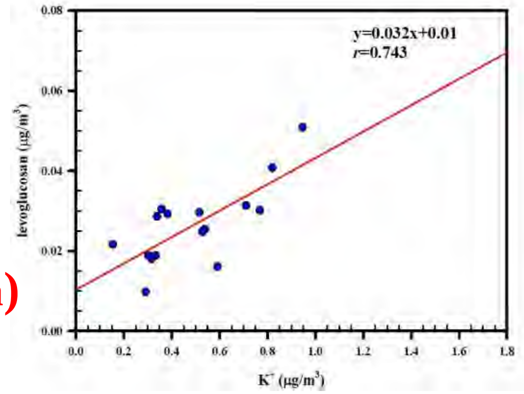


Xiaogang
(Urban, industrial)



NPUST
(Background, inland)

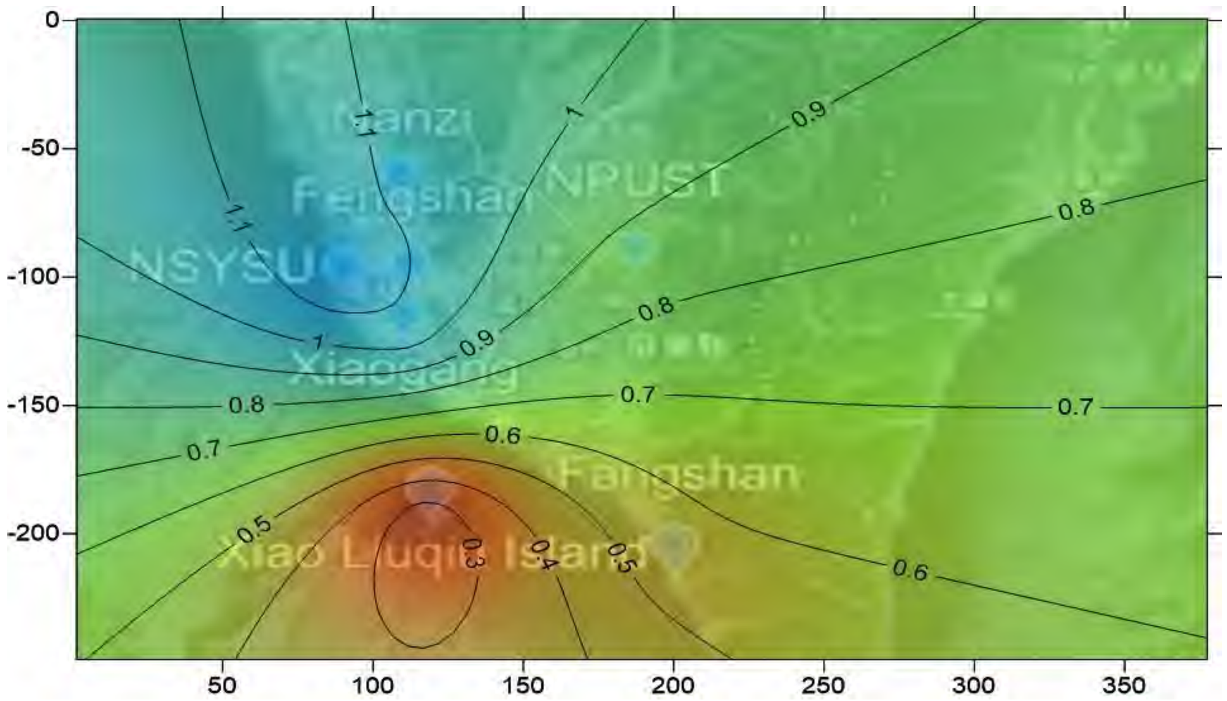
Xiaoliuqiu
(Background,
surrounded by the sea)



Biomass burning

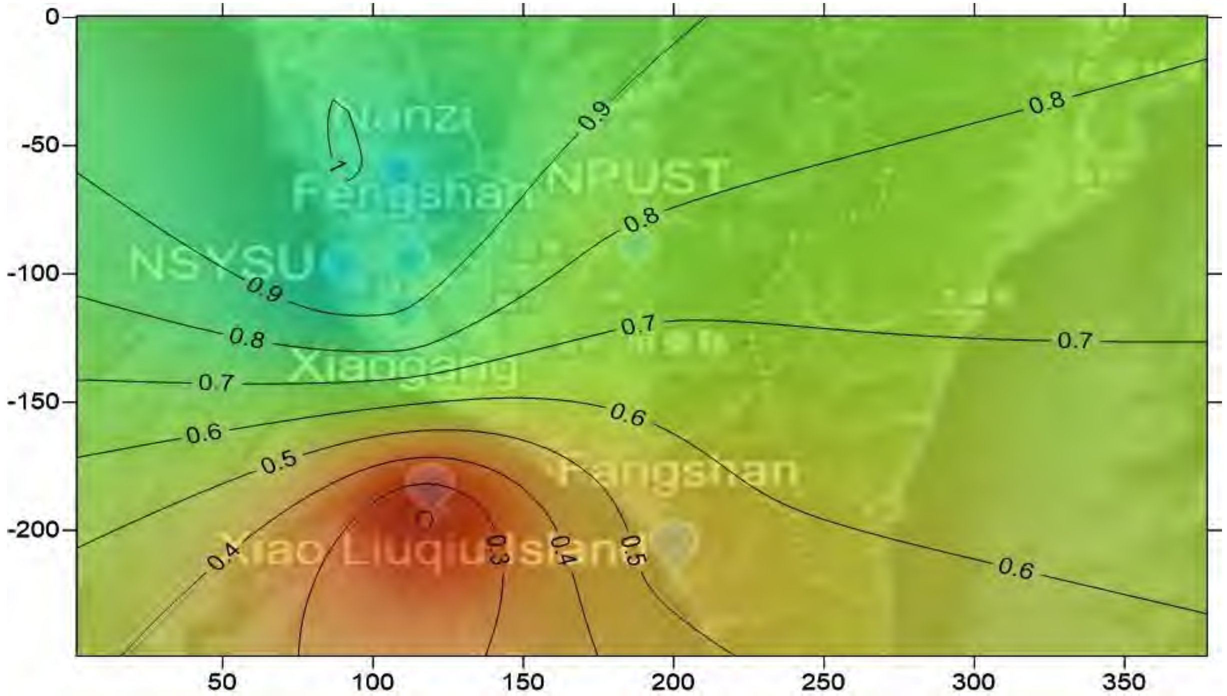
IOPs 1–4 average NRs

Daytime NR contour

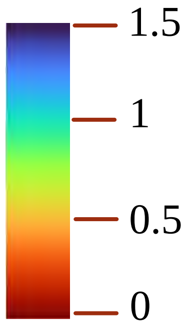


NR greater than 1➔ alkaline properties

Nighttime NR contour

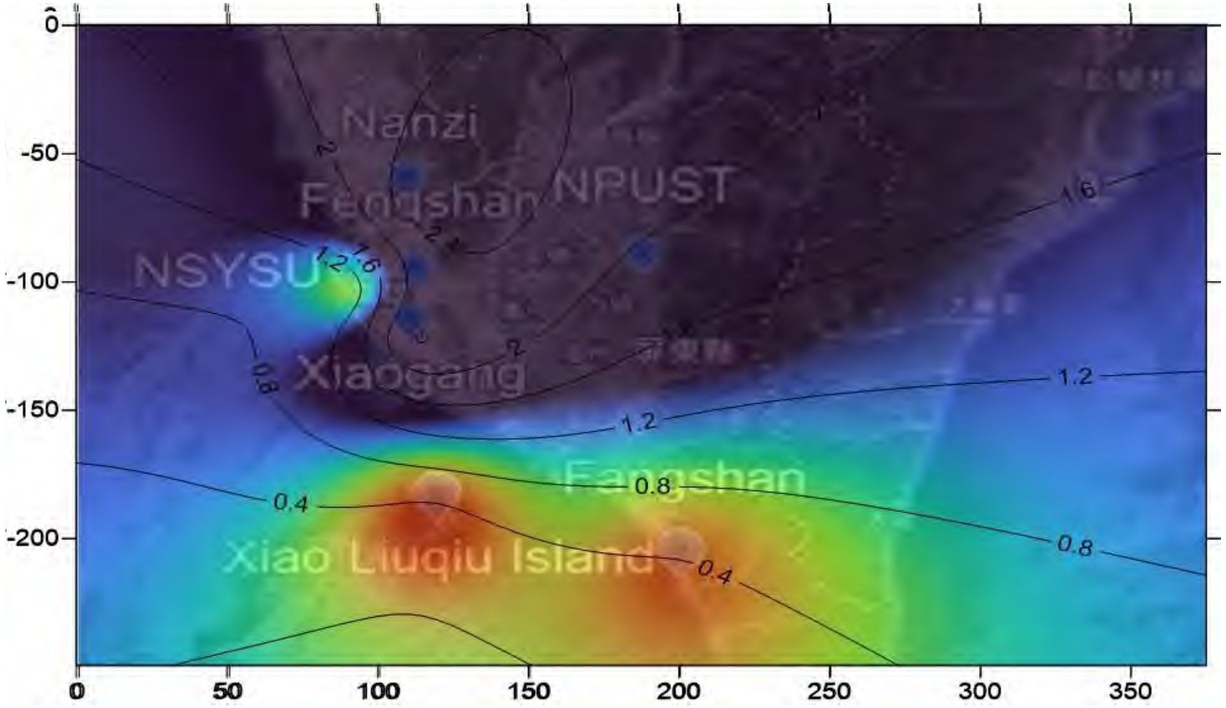


NR less than 1➔ acidic properties



At daytime on Feb. 28
IOP 2

Daytime NR
contour

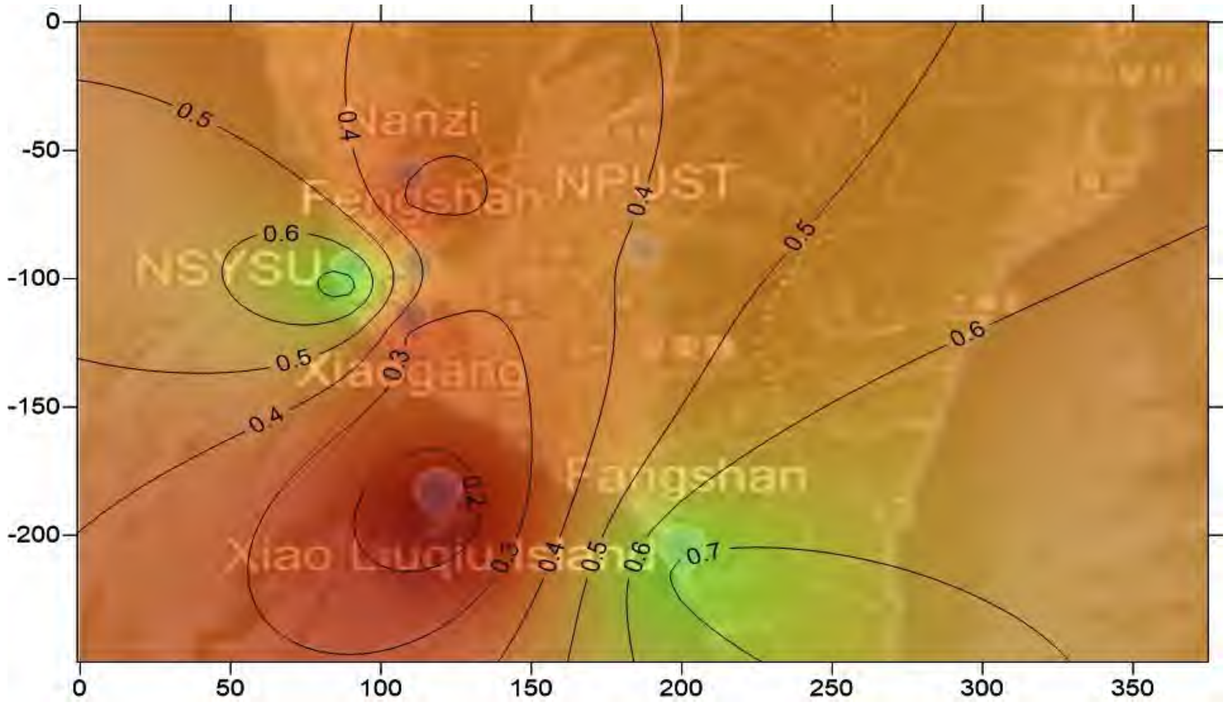


Strong alkaline

NR greater than 1➔ alkaline properties

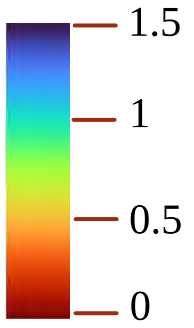
At nighttime on Feb. 28
IOP 2

Nighttime NR
contour

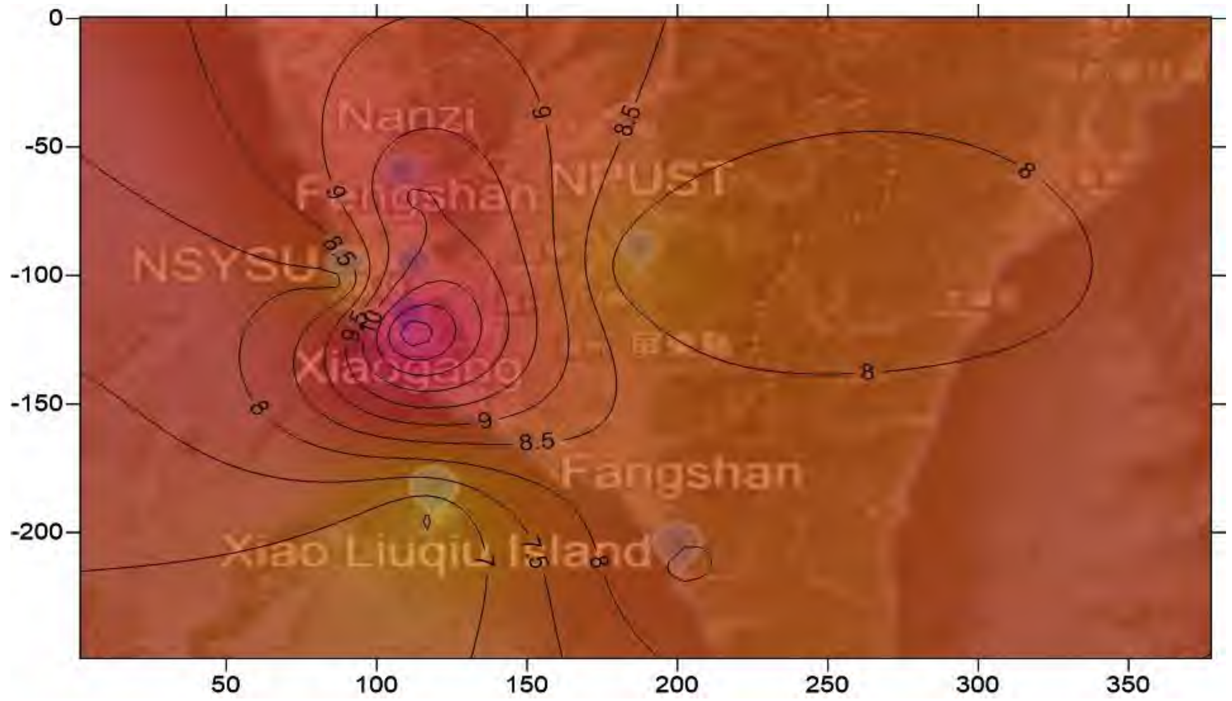


NR less than 1➔ acidic properties

Strong acidic

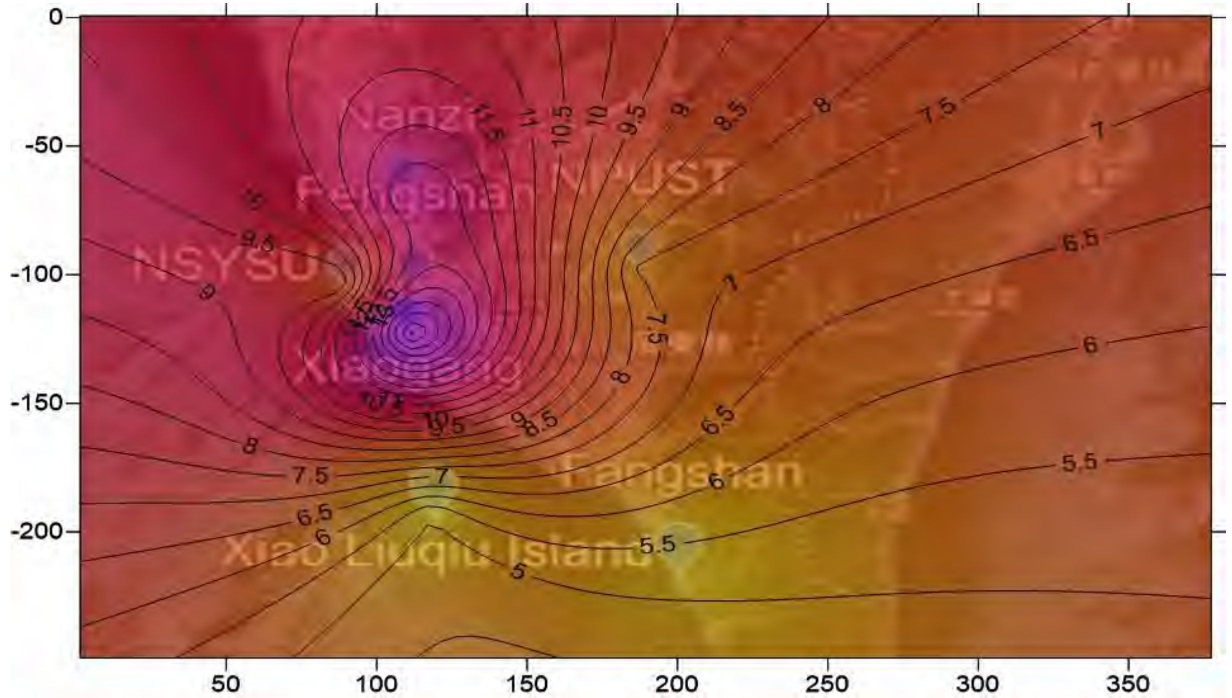


Daytime photochemical products in $PM_{2.5}$

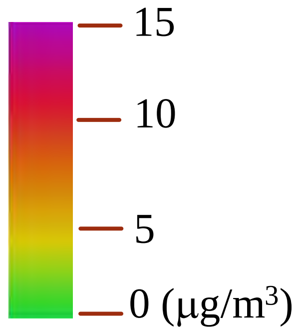


Sum of conc. of NH_4^+ + SO_4^{2-} + NO_3^-

Nighttime photochemical products in $PM_{2.5}$

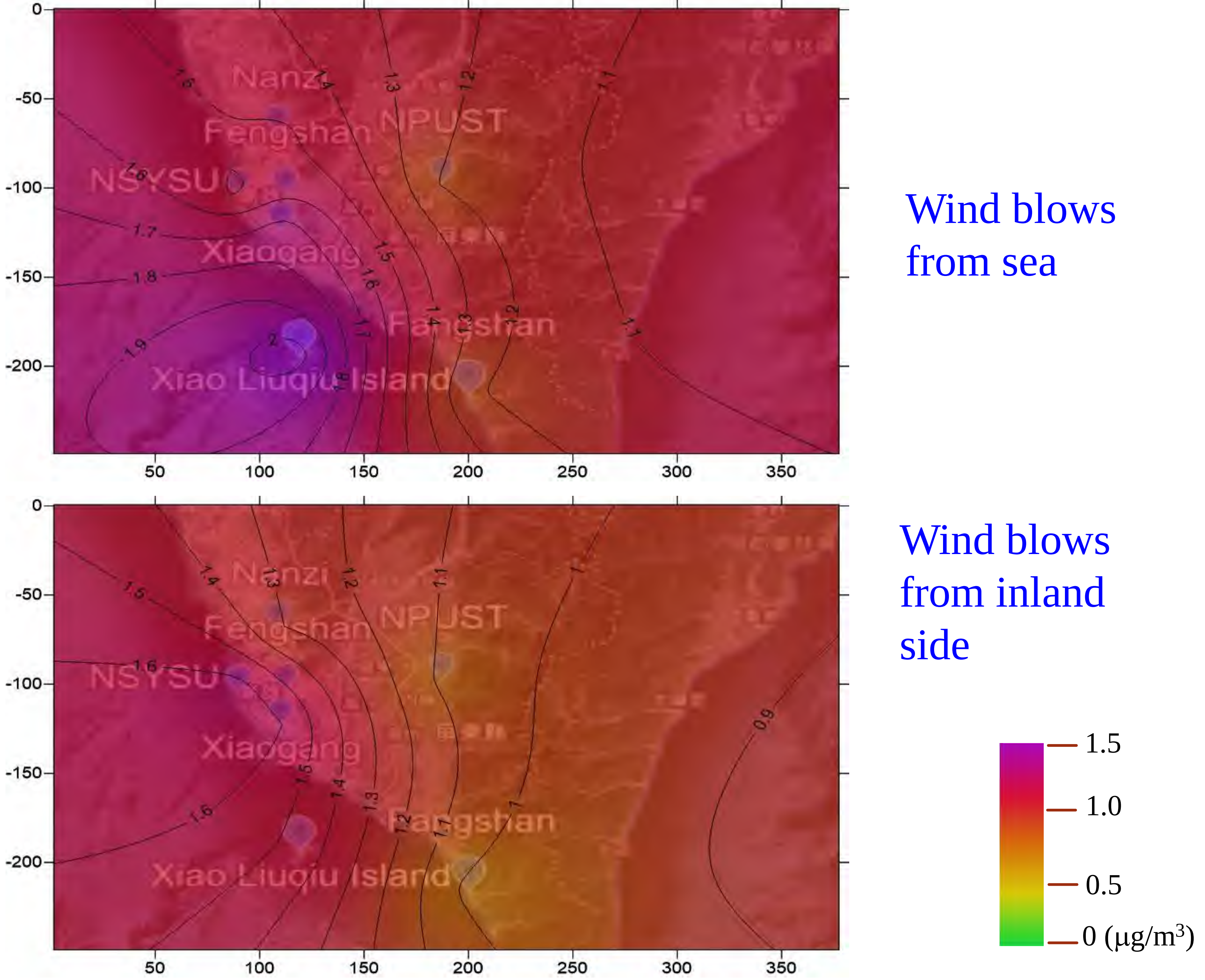


Less dispersion at night



Sea spray in $PM_{2.5}$ in daytime

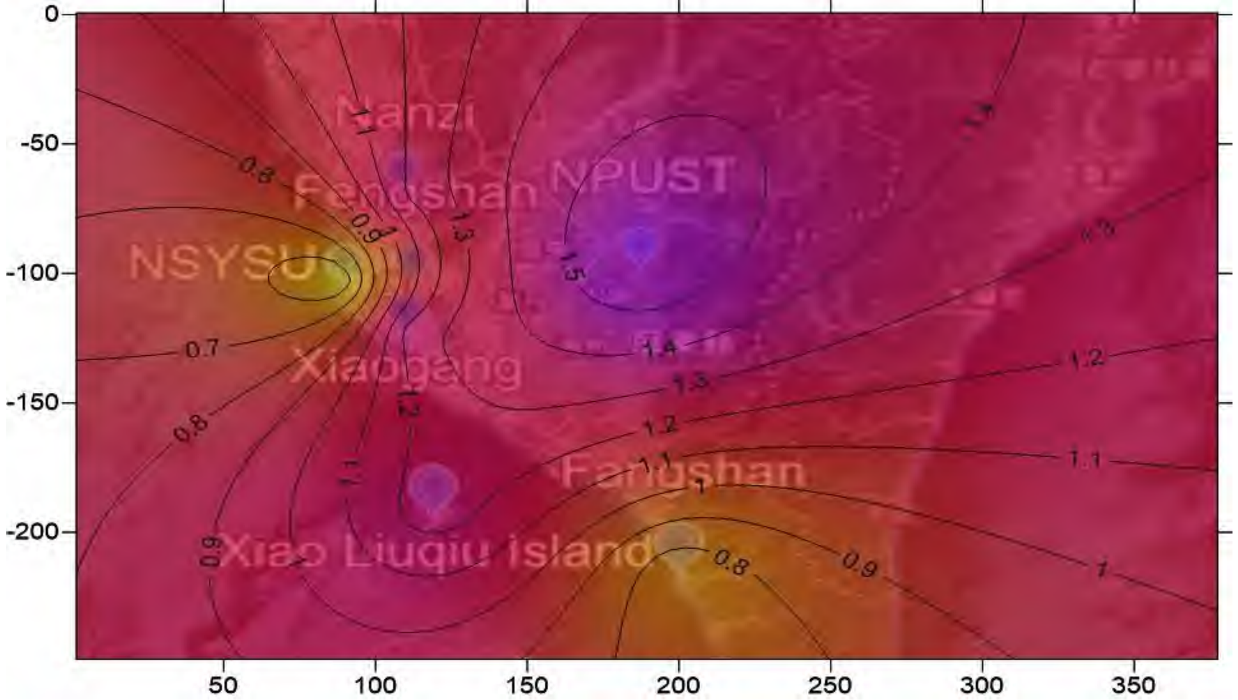
Wind blows from sea



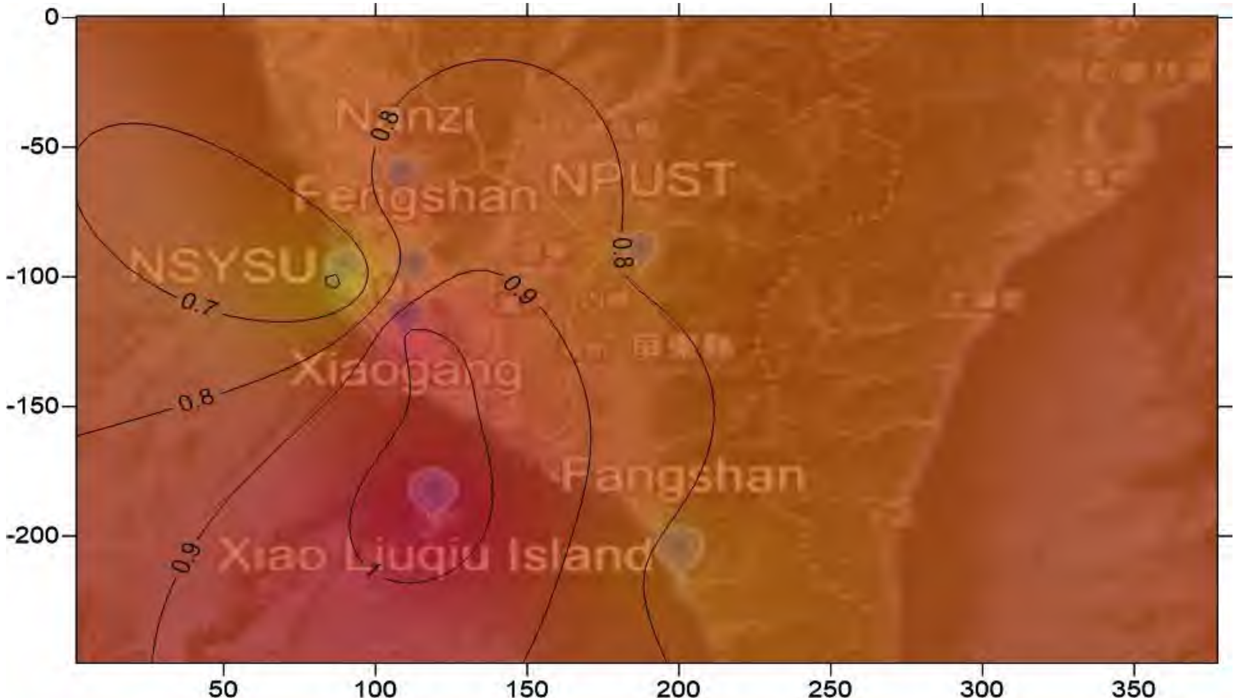
Sea spray in $PM_{2.5}$ in nighttime

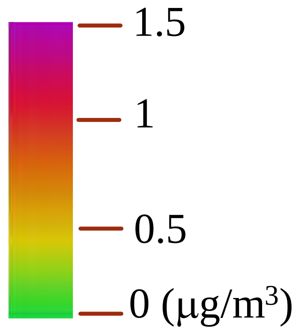
Wind blows from inland side

Crustal matters in $PM_{2.5}$ in daytime



Crustal matters in $PM_{2.5}$ in nighttime





Enrichment Factor

- Enrichment factor (EF) is defined as the relative abundance of metallic elements to reference element to explore the correlation between $PM_{2.5}$ and crustal materials . The EF is expressed as follows (Zhang et al., 2002):

$$EF = \frac{\left(\frac{Tr}{Ref}\right)_{PM}}{\left(\frac{Tr}{Ref}\right)_{crust}}$$

where Tr：trace elements

Ref：reference elements (e.g. Al, Fe, and Si)

$(Tr/Ref)_{PM}$ ：concentration ratio of trace elements to reference element in the suspended particles

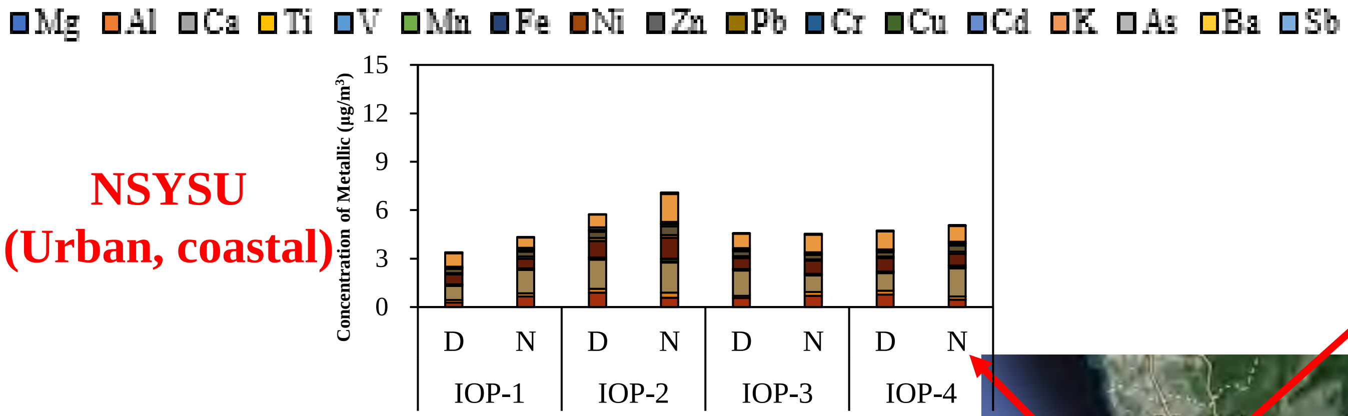
$(Tr/Ref)_{crust}$ ：concentration ratio of trace elements to reference element in the crustal materials

- In this study, Al was selected as the reference element for determining the enrichment factor of metals.

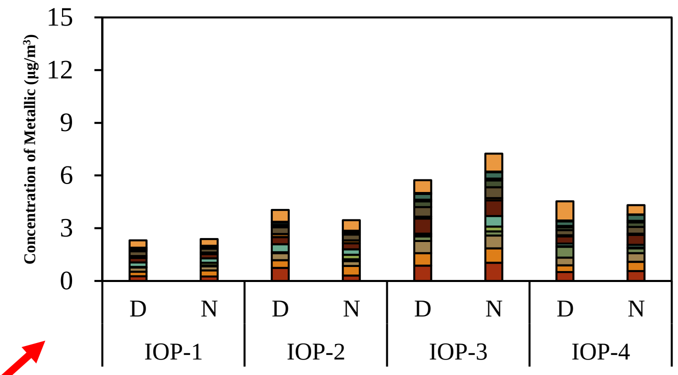
(1) If EF≦10, the elements mainly came from crustal and/or marine contribution.

(2) If EF>10, the elements mainly came from non-crustal sources.

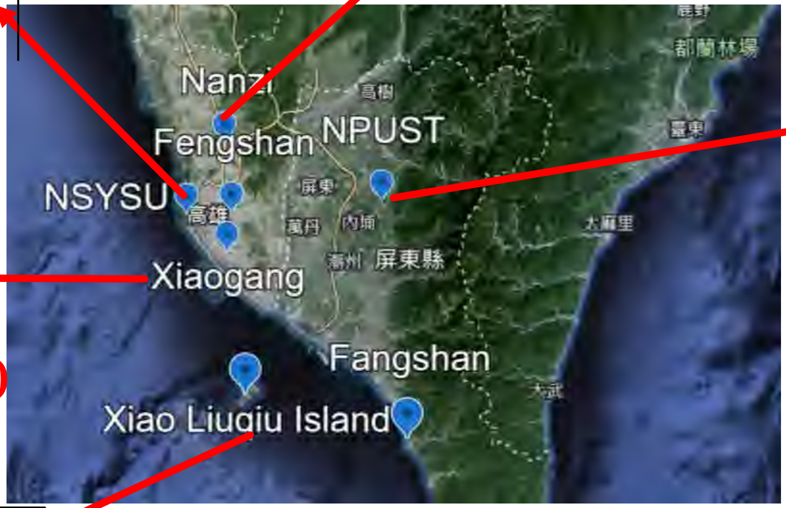
Metallic Elements of $PM_{2.5}$

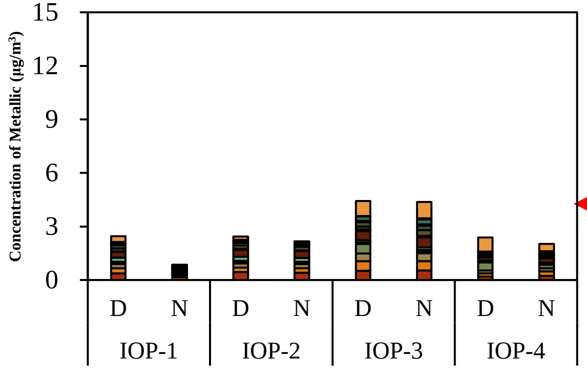


NSYSU
(Urban, coastal)

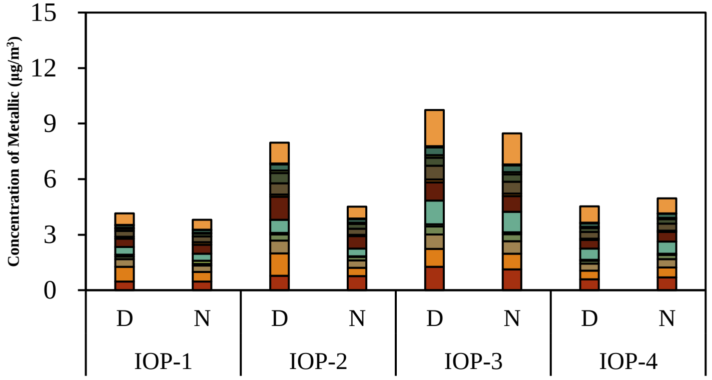


Nanzi
(Urban, industrial)



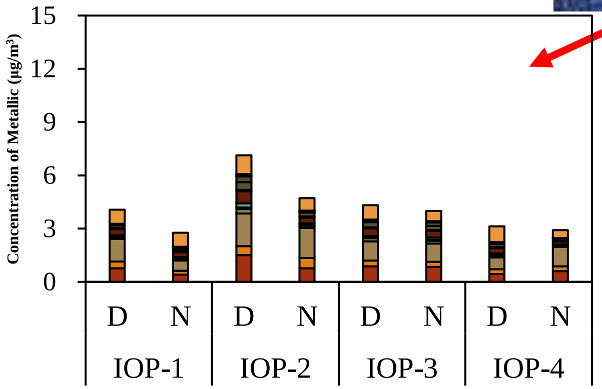


Xiaogang
(Urban, industrial)



NPUST
(Background, inland)

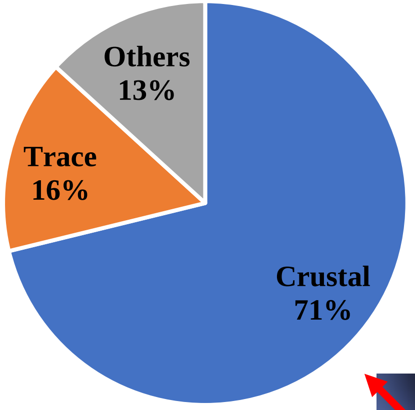
Xiaoliuqiu
(Background,
surrounded by the sea)



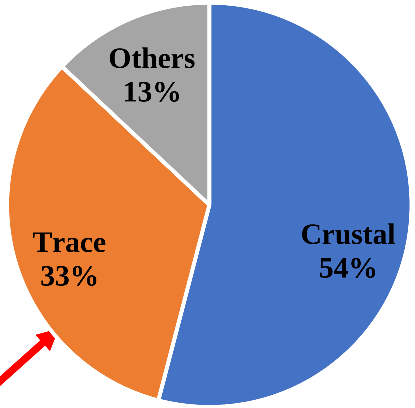
- The crustal elements Mg, Al, and Ca were more prominent at NSYSU and Xiaoliuqiu,
- While Mn, Ni, Zn, and Pb were more notable at Nanzi and Xiaogang stations.
- K at each location was also notable, indicating a potential influence from biomass burning.

Metallic Elements of $PM_{2.5}$

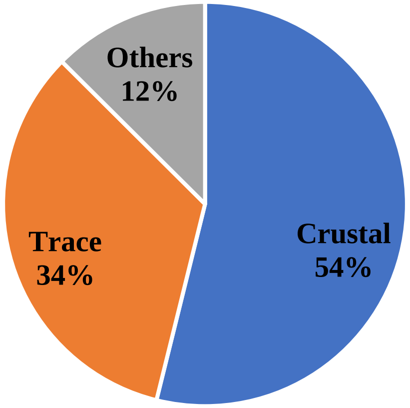
NSYSU
(Urban, coastal)

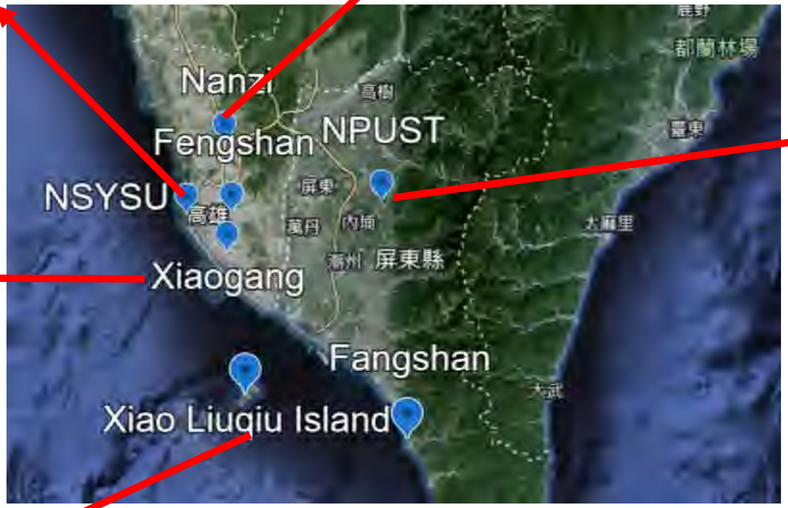


Nanzi
(Urban, industrial)

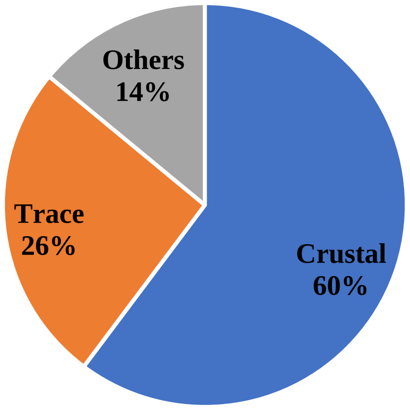


Xiaogang
(Urban, industrial)

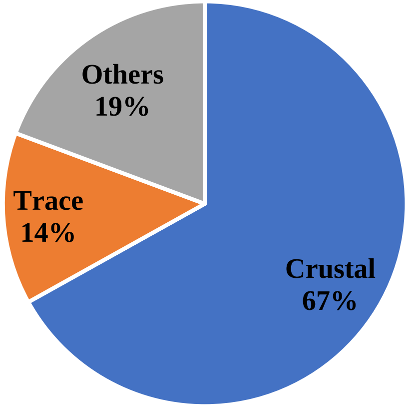




NPUST
(Background, inland)

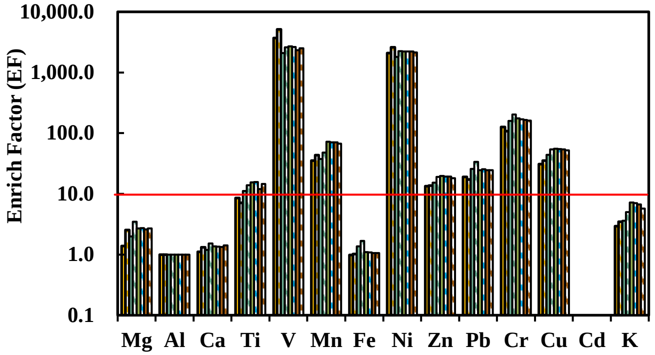


Xiaoliuqiu
(Background,
surrounded by the sea)

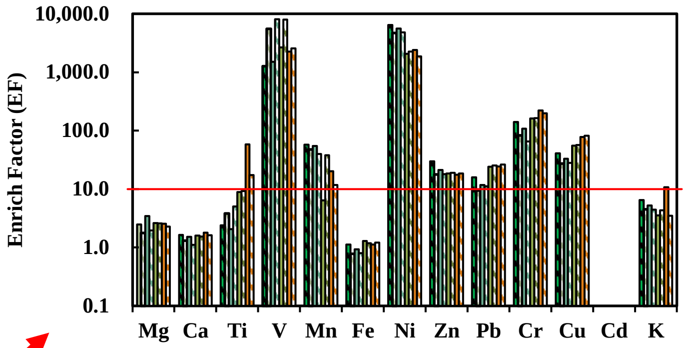


- In this study, the crustal metals include Al, Ca, Ti, Fe and K, and the trace metals were included V, Mn, Ni, Zn, Pb, Cr, Cu, and As.
- The percentage of crustal elements were in NSYSU (coastal) and Xiaoliuqiu (offshore island) higher than those at other locations.
- While percentage of trace elements were at Nanzi, Xiaogang and NPUST (industrial and inland region) were higher than those at other locations.

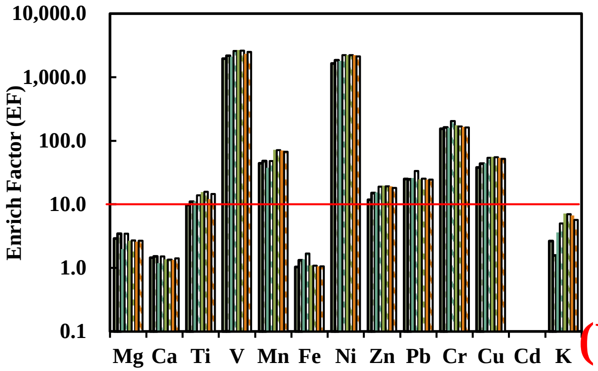
Enrichment Factor



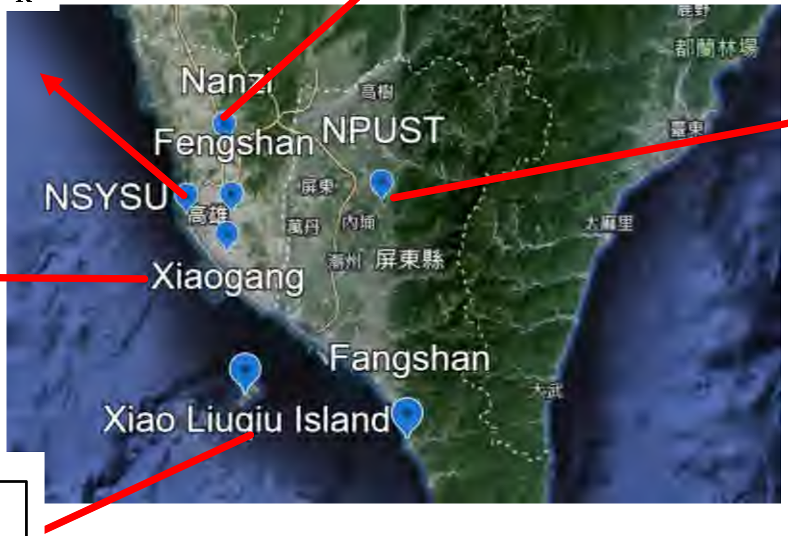
NSYSU
(Urban, coastal)



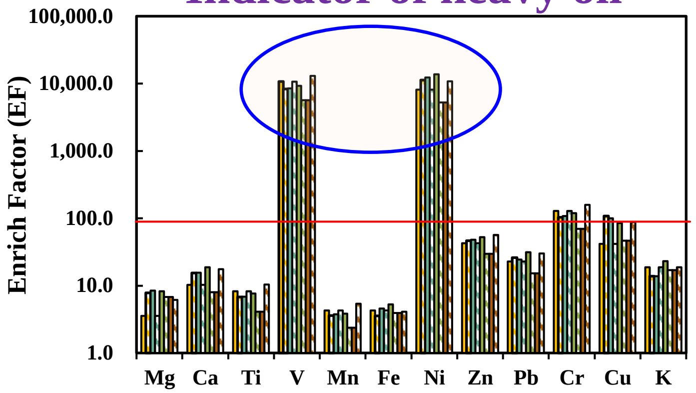
Nanzi
(Urban, industrial)



Xiaogang
(Urban, industrial)

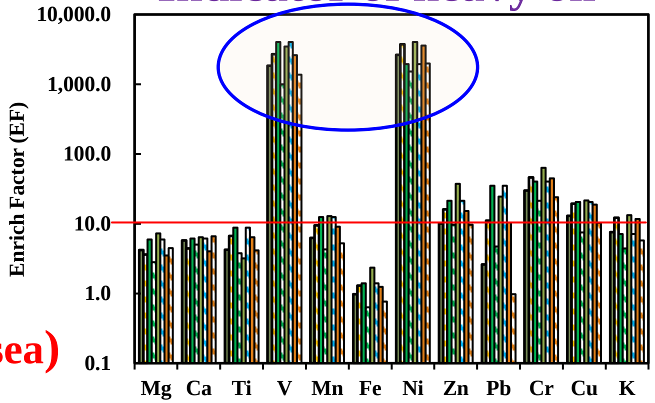


Indicator of heavy oil



NPUST
(Background, inland)

Indicator of heavy oil



Xiaoliuqiu
(Background, surrounded by the sea)

- At all locations, the main trace elements with EFs higher than 10 were V, Ni, Zn, Pb, Cr, Cu, and K, indicting that these location were affected by anthropogenic sources.
- The results indicate that the KPAQZ was influenced by various sources of anthropogenic pollution during the sampling period.
- Notably, the background monitoring stations at Xiaoliuqiu and NPUST were likely significantly impacted by long-range transport.

Conclusions (1/4)

- The primary ionic constituents of atmospheric particulates are sulfate (SO_4^{2-}), nitrate (NO_3^-), and ammonium (NH_4^+). Among the organic acids, oxalate is the predominant species.
- **Sulfate** consistently exhibits **the highest concentrations** across both urban and background locations, with particularly elevated levels observed in the **Xiaogang** area. This suggests that the predominant sources of these particulates are secondary organic aerosols (SOAs) and secondary inorganic aerosols.
- At NPUST, an inland background location, concentrations of chloride (Cl^-) and sodium (Na^+) in aerosols are lower than those in the coastal cities of Nanzi and Xiaogang. This indicates that the concentration and proportion of sea salt aerosols are lower in inland areas compared to coastal regions.

Conclusions (2/4)

- The oxalate-to-sulfate ratios (**Ratio of Oxalate/sulfate**), irrespective of urban or background locations, range from 5.87% to 11.83%, with an average of 8.05%. In Xiaogang, NSYS and Xiaoliuqiu, the average O/S during the day is higher than that at night, indicating that there is more **organic** photochemical production potential during the day, especially in NSYS and Xiaoliuqiu, which are both near the sea.
- During the sampling period, the concentration of levoglucosan in aerosols ranged from 20 to 80 ng/m^3 in both coastal and inland background areas, indicating **a contribution from biomass burning.**

Conclusions (3/4)

- The average inositol content in $PM_{2.5}$ across various locations ranges from 0.2 to 1.5 μg/m³, indicating **a significant presence of fungal metabolic byproducts in aerosols.**
- At NPUST, representing the background area, concentrations of metals such as vanadium (V), manganese (Mn), nickel (Ni), zinc (Zn), lead (Pb), chromium (Cr), and copper (Cu) in aerosols are consistently lower than those found in the urban and industrial areas of Nanzi and Xiaogang. This suggests that urban activities, including transportation and industrial emissions, significantly contribute to atmospheric metal levels.
- The composition of metallic elements in coastal and offshore areas were primarily dominated by crustal elements (Al, Ca, Ti, Fe and K).

Conclusions (4/4)

- Industrial and inland regions were characterized mainly by trace metal elements (V, Mn, Ni, Zn, Pb, Cr, Cu, and As).
- Inland site (NPUST) and background site (Xiaoliuqiu) were significantly influenced by the long-range transport.

Contact

- The comprehensive dataset of aerosol chemical properties, including ions, carbonaceous components, specific species, and metals, collected from six sites during the KPExs campaign, has been finalized and archived.
- Collaboration with interested research teams for discussions and data sharing is highly anticipated.
- Please contacts:

Ying I. Tsai (mtsaiyi@mail.cnu.edu.tw)

Thank you

Introduction

- This continuous cycle of pollution transport reduced the effective dispersion of air pollutants, leading to high level particulate matter (PM) and other harmful substances in the atmosphere.
- Over the past decade, there has been a highly effective strategy for reducing fine particulate matter ($PM_{2.5}$) pollution in the Kaoping region.
- However, the KaoPing Air Quality Zone includes various emission sources, such as industrial emissions, vehicle exhaust, and fugitive sources, which impact the air quality index.

Introduction

- Previous studies indicated that the dominant source of $PM_{2.5}$ at the KPAQZ was secondary inorganic aerosols, traffic exhausts, and road dust in spring and fall seasons. Yang et al. (2017) Shen et al. (2019)

- Since the contribution of industrial emission to primary $PM_{2.5}$ and gaseous precursors (i.e., SO_2, NO_x) of $PM_{2.5}$ plays a key role in the formation of $PM_{2.5}$, it is crucial to investigate the spatiotemporal distribution and chemical characteristics of $PM_{2.5}$ surrounding the anthropogenic source in KPAQZ for understanding the fingerprint of $PM_{2.5}$ in highly polluted regions.