Current status of atmospheric mercury studies in Southern Vietnam: insight into the application of UAV in mercury measurements

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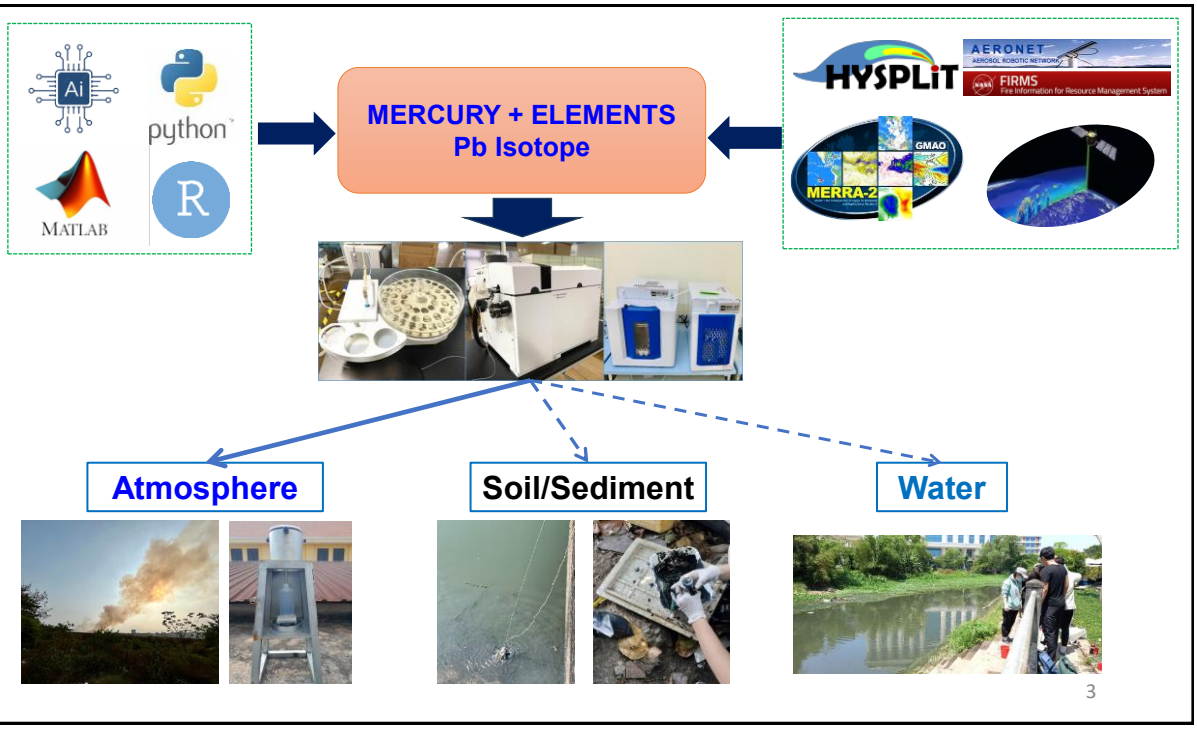

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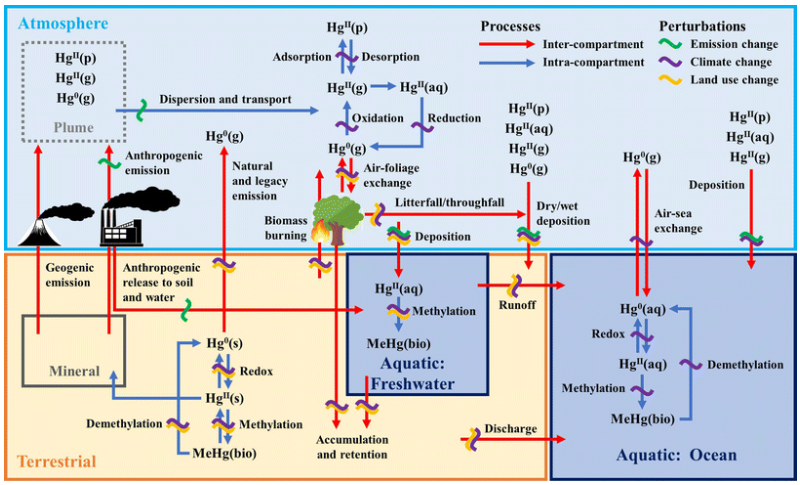
Why atmosphere?

(Obrist et al. 2018)

GEM
GOM
PBM



The atmosphere is **a key component of the biogeochemical cycle of Hg**, acting as a reservoir, transport mechanism, and facilitator of chemical reactions.

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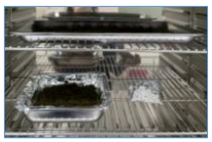
ATMOSPHERE

Biomonitoring



Characterization (spatial, temporal, vertical)



Source Apportionment and Transformation



Attempt to understand atmospheric **Hg speciation (GEM, GOM and PBM); size-fractionation of PBM; bio-accumulation of Hg**

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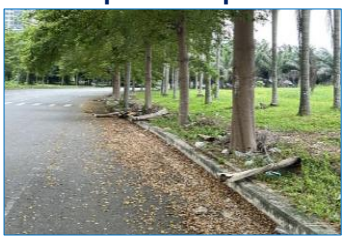
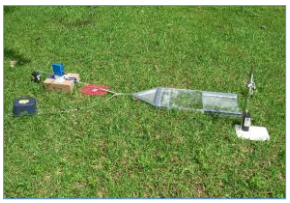
ATMOSPHERE

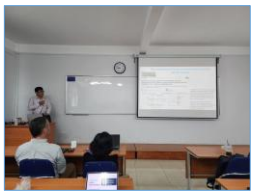
Atmospheric deposition



Hg re-emission (Dynamic flux chambers)



Lab experiments and expert training



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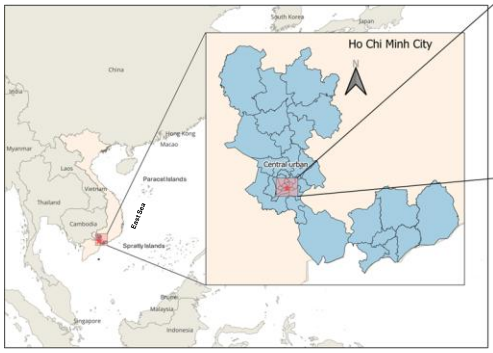
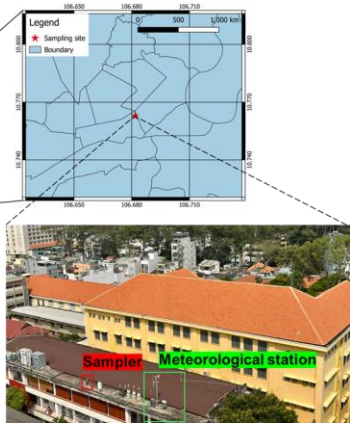
Study area – Ho Chi Minh City, Vietnam





HCMC, home to about 10 million people in Southern Vietnam, has poor environmental quality that **has rapidly worsened in the past two decades**.

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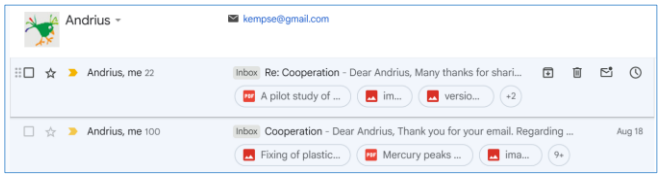
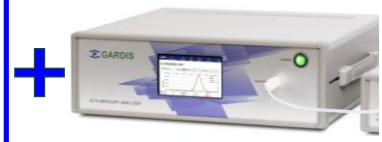
GARDIS-HgSpec

From Oct 2023-now

Dual-Chanel: TGM – GEM = RM





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MerPAS sampling in Ho Chi Minh City

Environmental and Climate change Canada – from June 2022

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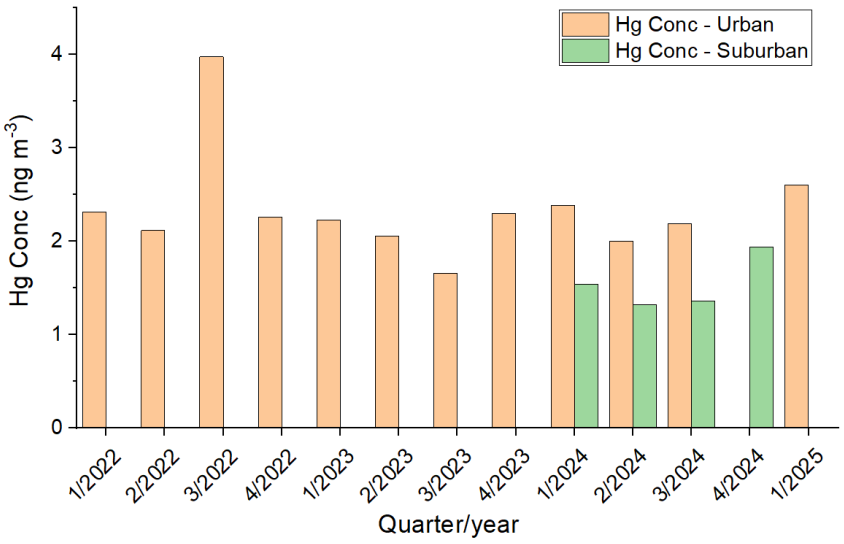
MerPAS results – Canada project



Quarter 1+4: dry season

Quarter 2+3: rainy season

Hg Conc dry > rainy

Urban > Suburban

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Publications

Chemosphere
Volume 307, Part 1, November 2022, 135707

Atmospheric particulate-bound mercury (PBM_{10}) in a Southeast Asia megacity: Sources and health risk assessment

Ly Sy Phu Nguyen [a b], To Thi Hien [a b], Minh Tri Truong [a b], Nguyen Doan Thien Chi [a b], Guey-Rong Sheu [c d]

Atmospheric Pollution Research
Volume 13, Issue 4, April 2022, 101366

Trans-boundary air pollution in a Southeast Asian megacity: Case studies of the synoptic meteorological mechanisms and impacts on air quality

Ly Sy Phu Nguyen [a b], Jackson Hian-Wui Chang [c d], Stephen M. Griffith [c], To Thi Hien [a b], Steven Soon-Kai Kong [c], Hoai Nam Le [e], Hsiang-Yu Huang [c], Guey-Rong Sheu [c f], Neng-Huei Lin [c f]

Atmospheric Environment
Volume 333, 15 September 2024, 120664

Spatiotemporal variations of atmospheric mercury at urban and suburban areas in Southern Vietnam megacity: A preliminary year-round measurement study

To Thi Hien [a b], Ly Sy Phu Nguyen [a b], Minh Tri Truong [a b c], Thi Dieu Huong Pham [a b], Tran Anh Ngan [a b], Tran Hoang Minh [a b], Le Quoc Hau [a b], Huynh Thien Trung [a b], Nguyen Thi Thanh Nhan [a b], Nguyen Thao Nguyen [a b]

Atmospheric Pollution Research
Volume 14, Issue 8, August 2023, 101813

Characteristics of total gaseous mercury at a tropical megacity in Vietnam and influence of tropical cyclones

Ly Sy Phu Nguyen [a b], Thi Dieu Huong Pham [a b], Minh Tri Truong [a b], Anh Ngan Tran [a b]

Home › Bulletin of Environmental Contamination and Toxicology › Article

Long-Range Atmospheric Mercury Transport from Across East Asia to a Suburban Coastal Area in Southern Vietnam

Published: 19 December 2023
Volume 112, article number 14, (2024) Cite this article

Bulletin of Environmental Contamination and Toxicology
Aims and scope →
Submit manuscript →

Ly Sy Phu Nguyen & To Thi Hien

Access this article

Characterization, driving mechanisms, source apportionment, health risk assessments of atmospheric Hg (GEM and PBM)

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Characterization – TGM/GEM

Site	Type	TGM/GEM (ng m^{-3})	Reference
HCMC Vietnam	Urban	2.49 ± 0.86	This study
HCMC Vietnam	Suburban	1.76 ± 0.50	This study
Taichung, Taiwan	Urban	6.14 ± 3.91	Huang et al., 2012
Nanjing, China	Urban	7.9 ± 7.0	Zhu et al., 2012
Seoul, Korea	Urban	3.72 ± 2.96	Han et al., 2014
Fukuoka, Japan	Urban	2.33 ± 0.49	Marumoto et al., 2015
Bronx, USA	Urban	1.92 ± 0.59	Zhou et al., 2018
Rochester, USA	Urban	1.66 ± 0.86	Zhou et al., 2018
Dartmouth, Canada	Urban	1.67 ± 1.01	Cheng et al., 2014
Beijing, China	Rural	3.22 ± 1.74	Zhang et al., 2013
Chuncheon, Korea	Rural	2.52 ± 1.80	Han et al., 2014
Kejimkujik National Park, Canada	Rural (coastal)	1.38 ± 0.20	Cheng et al., 2014
Jhongli, Taiwan	Suburban	2.61 ± 6.47	Sheu et al., 2019
Shanghai, China	Suburban	4.19 ± 9.13	Duan et al., 2017
Xiamen, China	Suburban	3.50 ± 1.21	Xu et al., 2015
Minamata, Japan	Suburban	1.90 ± 0.40	Marumoto et al., 2015

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Characterization – PBM

Sampling sites	Size	PBM (pg m^{-3})	Reference
Ho Chi Minh City (urban)	TSP	60.5±39.4	This study
Ho Chi Minh City (Suburban)	TSP	26.4±16.6	This study
Beijing, China	TSP	220±130	Huang et al., 2019
Beijing, China	TSP	573±551	Schleicher et al., 2015
Shanghai, China	TSP	318±144	Han et al., 2018
Shanghai, China	TSP	233–529	Xiu et al., 2005
Xi'an, China	TSP	640±540	Xu et al., 2017
Nanjing, China	PM_{10}	1100±570	Zhu et al., 2014
Qingdao, China	TSP	Dust: 290; non-dust: 190	Zhang et al., 2015
Kathmandu Valley, Nepal	TSP	850.5±926.8	Guo et al., 2017
Dhulikhel, Nepal	TSP	108.7±86.2	Guo et al., 2021
Seoul, Korea	TSP	6.8±6.5	Kim et al., 2012
Tokyo, Japan	PM_{10}	98±51	Sakata and Marumoto, 2002
Detroit, USA	TSP	94	Keeler et al., 1995
Poznan, Poland	TSP	40±50	Siudek et al., 2015
Zabrze, Poland	PM_{10}	63.6±53.0	Pyta, 2016
Terra Nova Bay, Antarctica	PM_{10}	87±8	Illuminati et al., 2020

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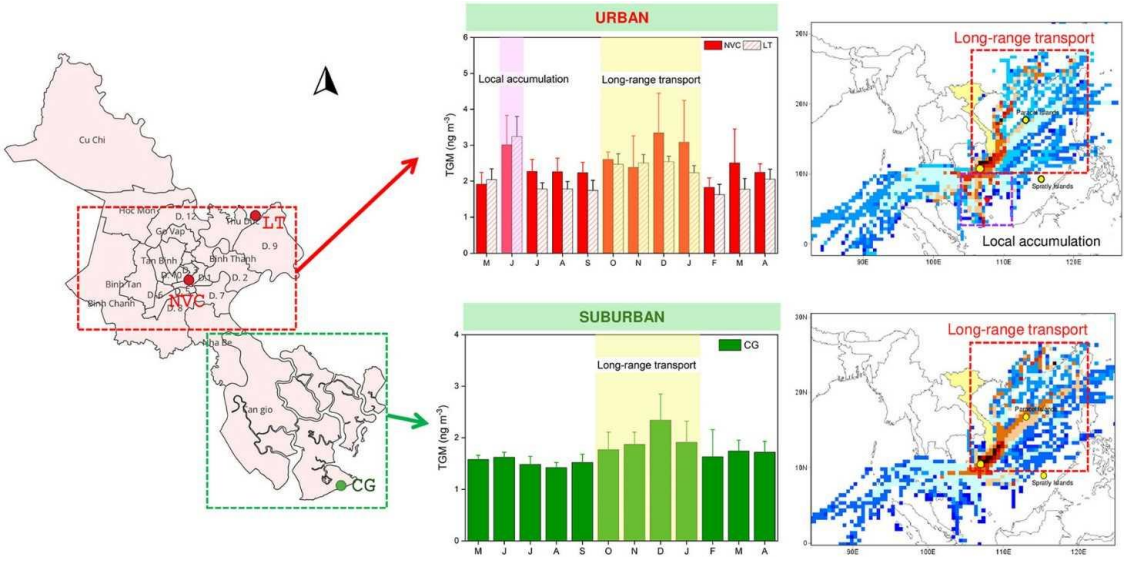
Seasonal variation + Factors



(Hien et al., 2024)

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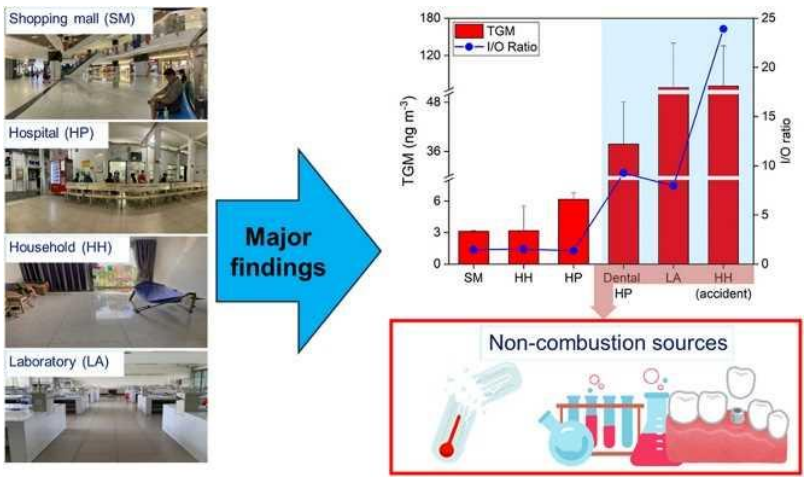
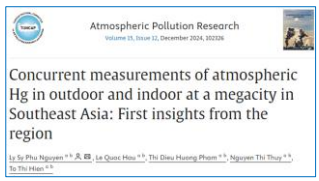
Hg indoor/outdoor at various sites




Atmospheric Pollution Research

Concurrent measurements of atmospheric Hg in outdoor and indoor at a megacity in Southeast Asia: First insights from the region

For indoor environment, ***non-combustion Hg sources play a more important role as compared to the combustion sources***

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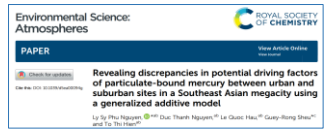
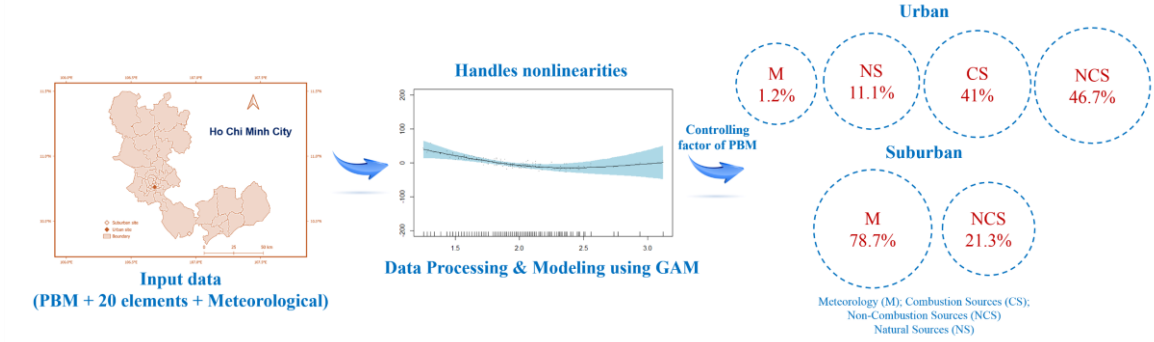
GAM model + PBM





We indicated the effectiveness of data-driven approaches in disentangling complex PBM-environment relationships and suggest the contrasting roles of anthropogenic emissions and meteorological processes in shaping PBM levels in urban and suburban areas.

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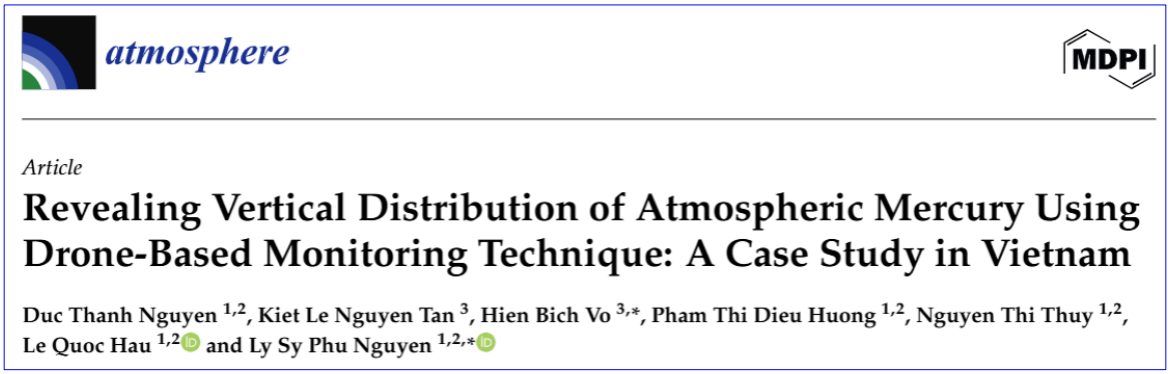
Drone-Based monitoring – case study in Vietnam



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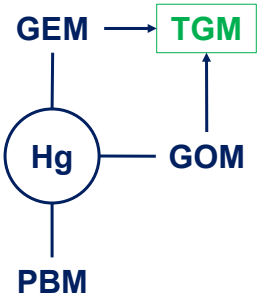
Motivation



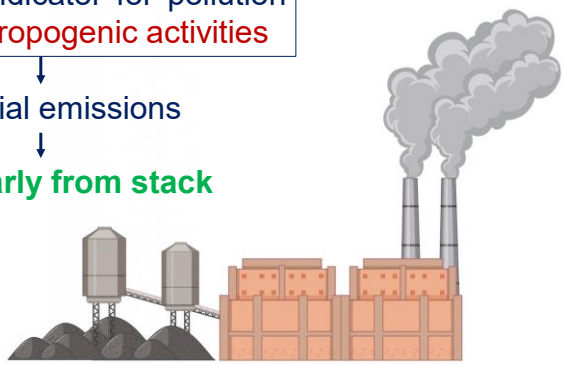
Hg is a key indicator for pollution driven by anthropogenic activities

↓

Industrial emissions

↓

Particularly from stack



→ Monitoring vertical Hg profiles is essential for providing a comprehensive understanding of pollutant (i.e. TGM) transport pathways in the atmosphere

→ Emission plumes from stacks are critical but lack study to investigate

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Experimental setup

The UAV's average flight time was about 12 min, with ascent and descent speeds set at 2 m/s to save battery and stay safe.

The research was conducted at Vietnamese-German University, surrounding by several industrial zones.

→ 36 paired samples (concurrent measurement drone + ground) collected at the VGU sports field.

The multirotor UAV DJI Matrice 200

TGM sampling followed the US EPA's IO-5 protocol

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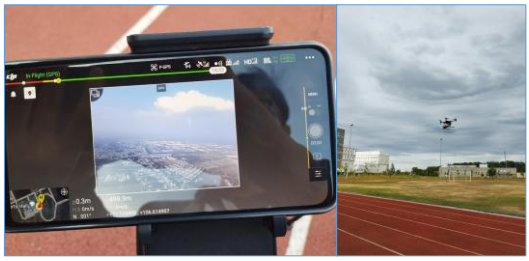
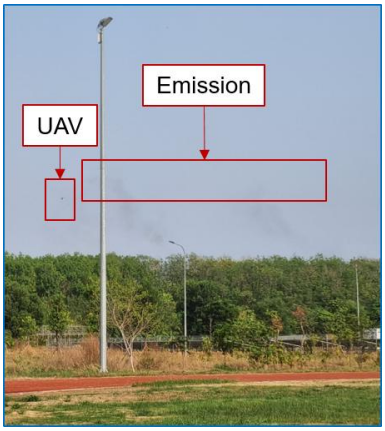
The UAV was operated using the DJI mobile application installed on a smartphone





Three emission sources originating from stacks

- Garment manufacturing
- Plywood processing
- Packaging production

→ The measurement site is located in an open field at 9:00 – 16:00, allowing efficient air circulation and facilitating uniform pollutant dispersion.

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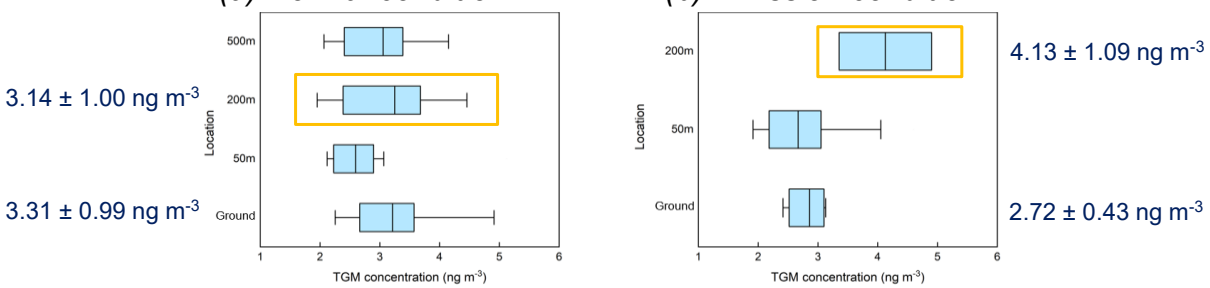
TGM concentrations distribution – overall

(a) Normal condition

(b) Emission condition



- Under normal conditions, TGM remains relatively stable with slightly elevated at ground level, suggesting that TGM sources are primarily located near the surface (local source).
- Under emission condition, TGM exhibit significant variation across altitudes, reflecting the impact of emission sources and atmospheric dispersion processes.

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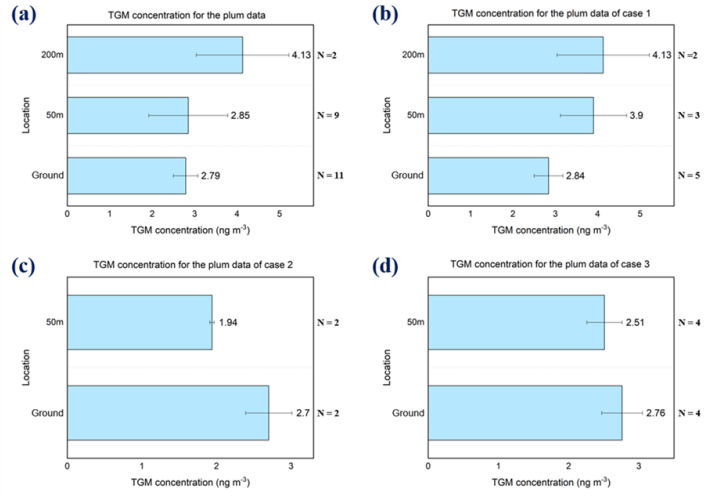
Three scenarios

The collected results can be categorized into three different cases for emission conditions.



1. Ground level < higher altitude
2. Ground level > higher altitude
3. Ground level ~ higher altitude

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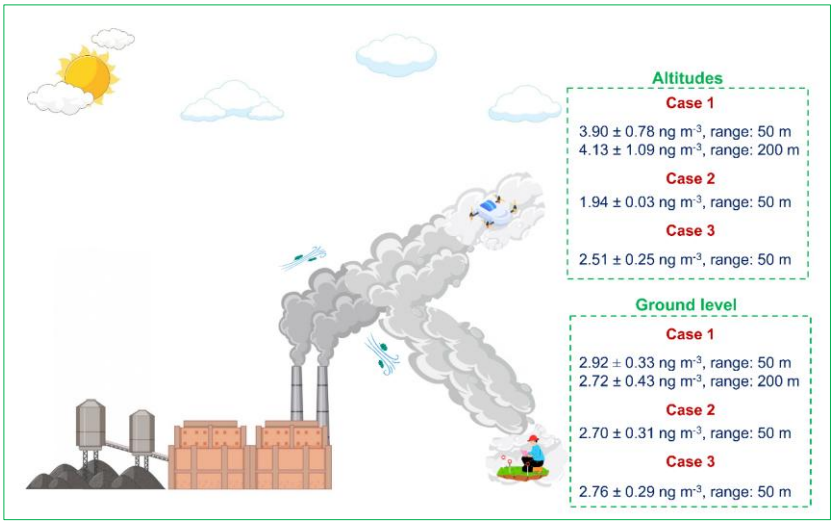
Three scenarios



- Plume emission has a complex transport path after emitting.
- UAV is effective in “real” capture of the impacts of pollution from the stack.
- Our study emphasizes the necessity of considering both emission characteristics and atmospheric conditions in developing local air quality management strategies.

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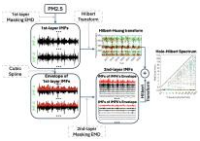
Future directions/publications

- ✓ Atmospheric deposition, re-emission and biomonitoring of Hg (publications)

- ✓ Size-fractionated atmospheric Hg and metals + Pb isotope



- ✓ AI/advanced mathematical methods for data analysis

- ✓ Passive sampling (MerPAS) (publications)

- ✓ Developing the automatic instrument to study atmospheric Hg chemistry

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