GEO-INFORMATICS AND SPACE TECHNOLOGY DEVELOPMENT AGENCY (PUBLIC ORGANIZATION)

Transboundary Air Pollution: Strengthening ASEAN–APCTT Cooperation through Integrated Technology, Policy, and Field Practices for Sustainable Air Quality 3 Feb 2026

The Spatial-Temporal Analysis of Air Pollution Zones Using Geo-Informatic Technology

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Office of Geo-Informatics Development and Application

Geo-Informatics and Space Technology Development Agency

INTRODUCTION

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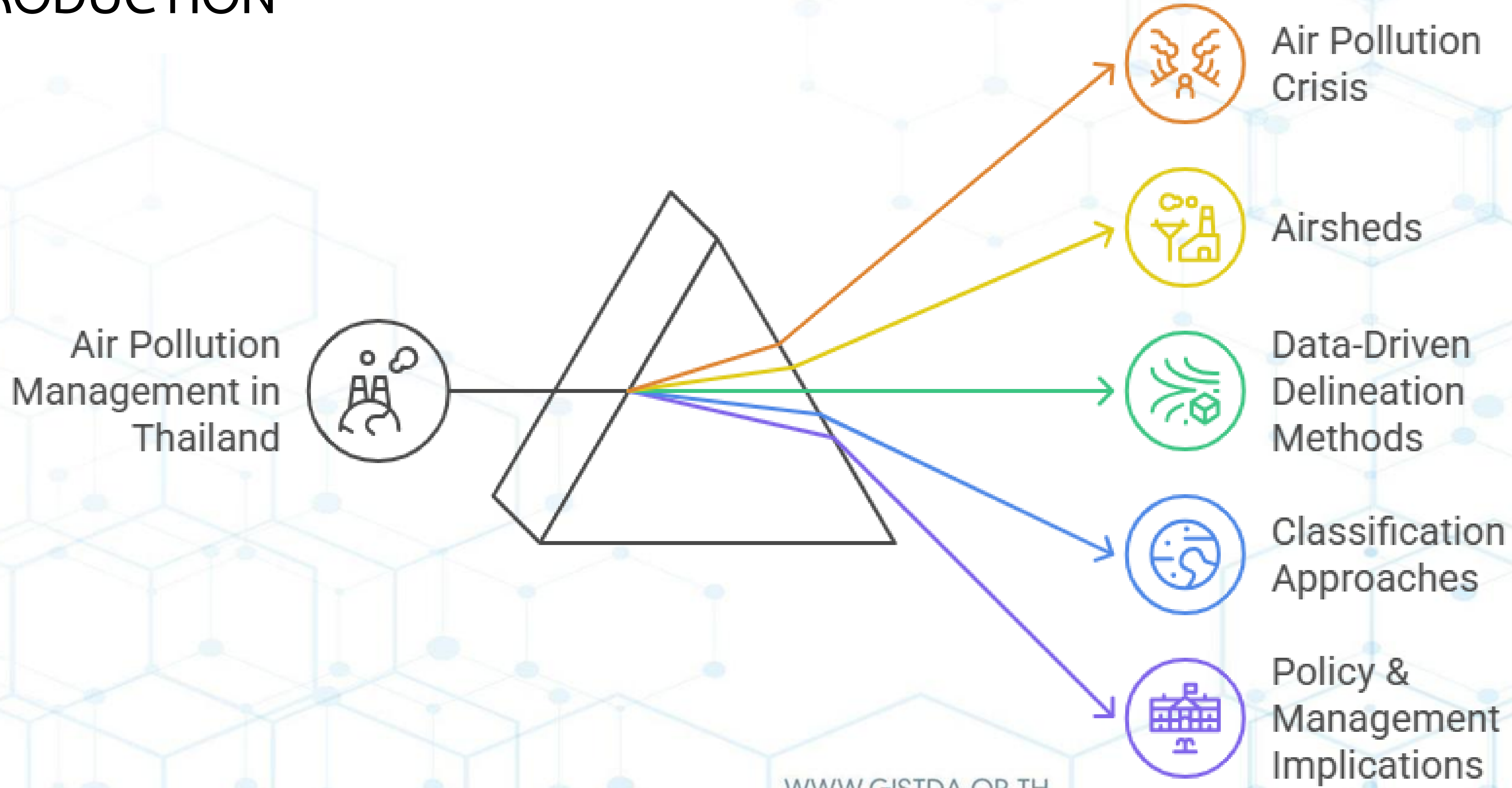


INTRODUCTION

- Air pollution from industry, vehicles, agricultural burning, and transboundary haze.
- Severe health risks (respiratory & cardiovascular diseases) demand urgent monitoring and mitigation.

INTRODUCTION

- Geographic zones where pollutants accumulate due to terrain and weather.
- Better than administrative boundaries for pollution management and policy.

INTRODUCTION

- Uses satellite DEM and meteorological data (wind, pressure, radiation).
- Machine learning (unsupervised clustering) identifies pollution patterns without pre-labeled data.

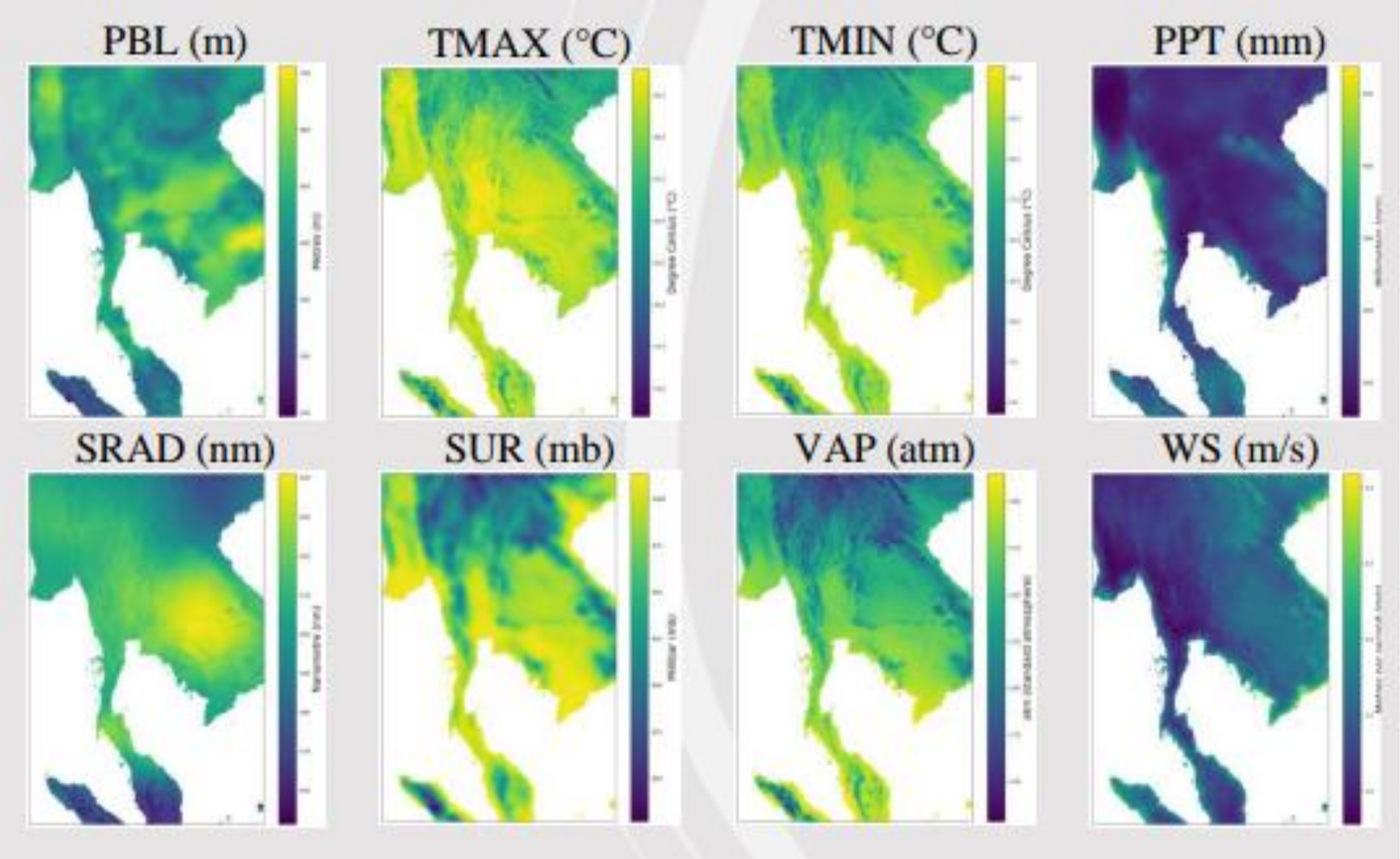
INTRODUCTION

- Geo-Informatic performance Classification for delineating airsheds in Thailand (Objective of work).

INTRODUCTION

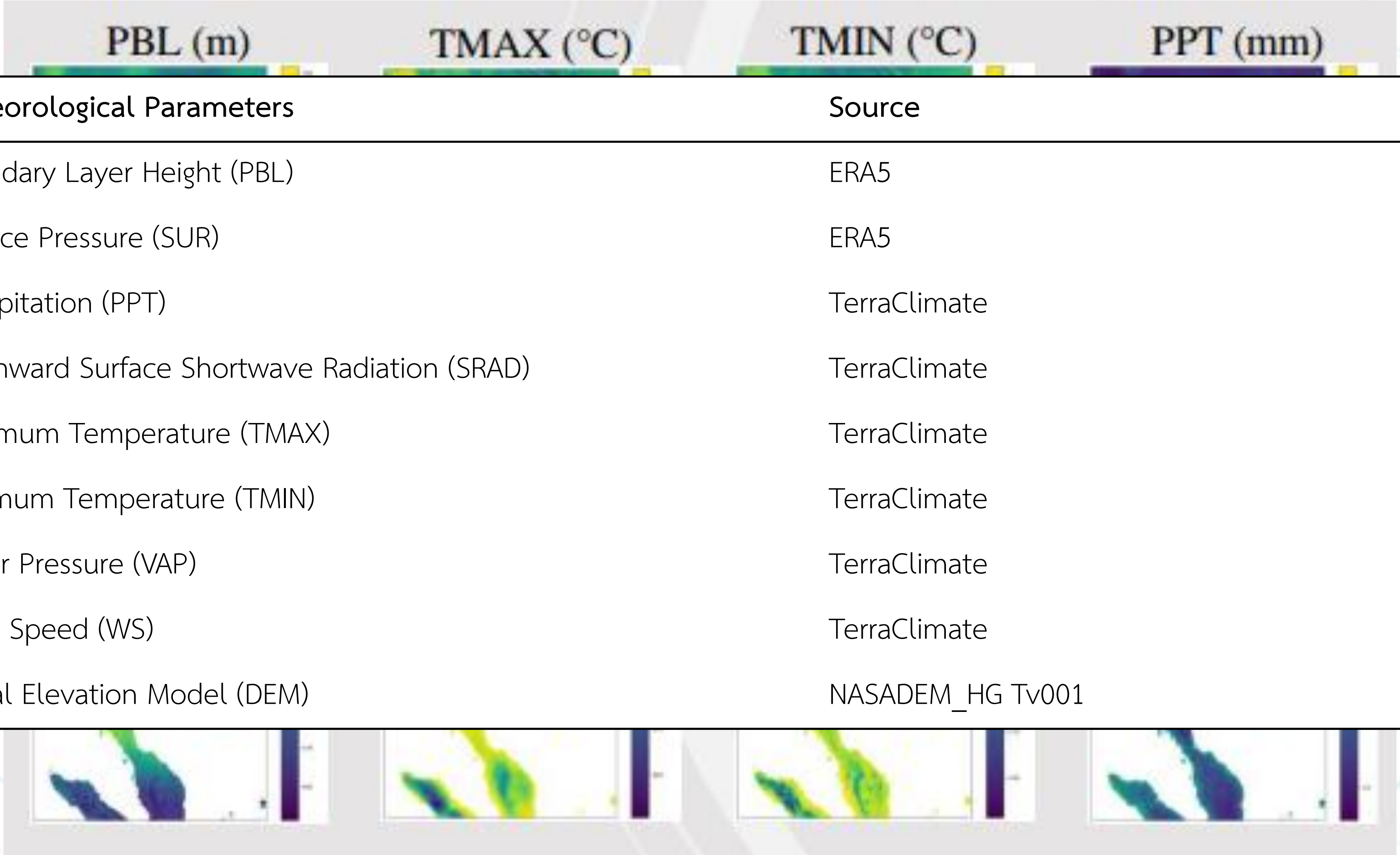
- Supports localized airshed maps for targeted pollution control

DATA COLLECTIONS



21-year monthly meteorological data with topographical features

DATA COLLECTIONS



Meteorological Parameters	Source
Boundary Layer Height (PBL)	ERA5
Surface Pressure (SUR)	ERA5
Precipitation (PPT)	TerraClimate
Downward Surface Shortwave Radiation (SRAD)	TerraClimate
Maximum Temperature (TMAX)	TerraClimate
Minimum Temperature (TMIN)	TerraClimate
Vapor Pressure (VAP)	TerraClimate
Wind Speed (WS)	TerraClimate
Digital Elevation Model (DEM)	NASADEM_HG Tv001

21-year monthly meteorological data with topographical features

MODEL PROCESSING

The Elbow Method is a fundamental technique for determining the optimal number of clusters (k) in unsupervised machine learning applications.

Step	Process Stage	Description	Role of Elbow Method
1	Data Preparation	Spatial data preprocessing (Object / Pixel level)	Not yet applied
2	Feature Analysis	Statistical parameter calculation (Mean / Mode)	Not yet applied
3	Clustering	K-Means / ISODATA implementation (testing k = 2–10)	Determines optimal k value
4	Region Finalization	Definitive geographical boundary delineation	Applies optimized k from Elbow

MODEL PROCESSING

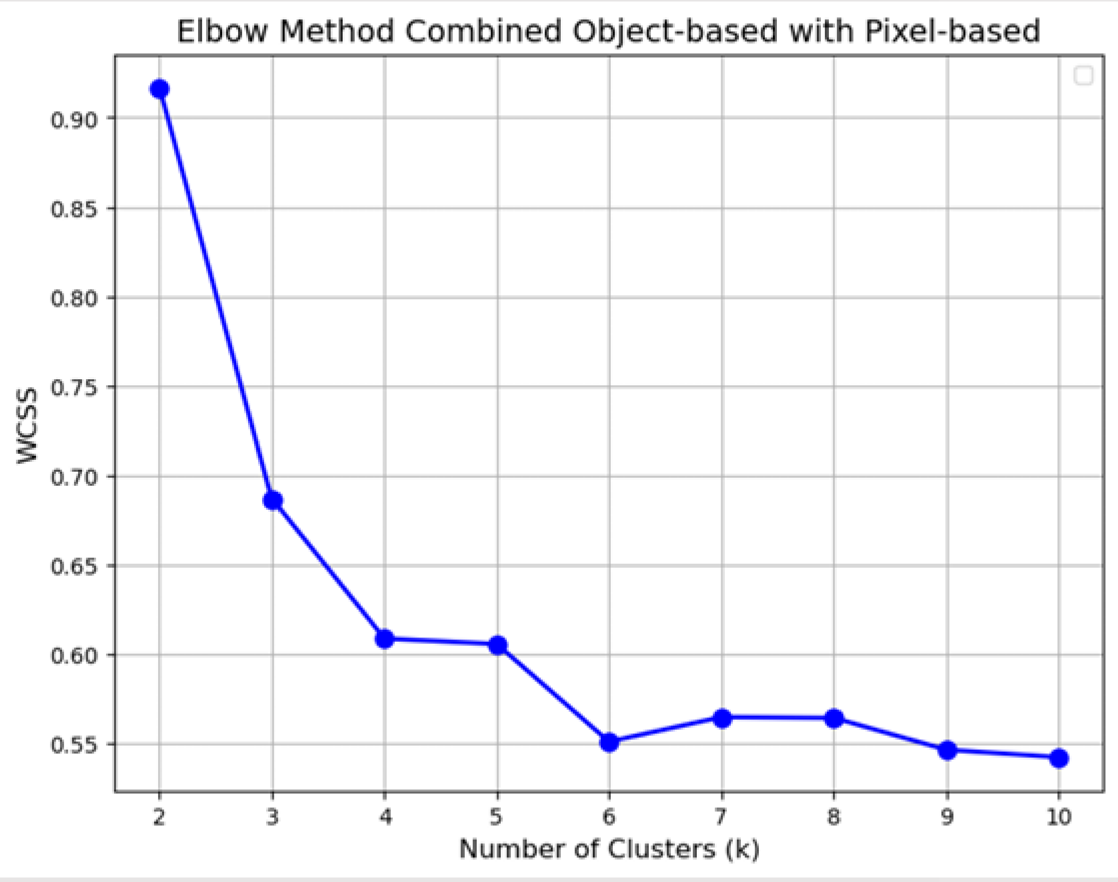
The Elbow Method is a fundamental technique for determining the optimal number of clusters (k) in unsupervised machine learning applications.

Within-Cluster Sum of Squares (WCSS) Calculation:

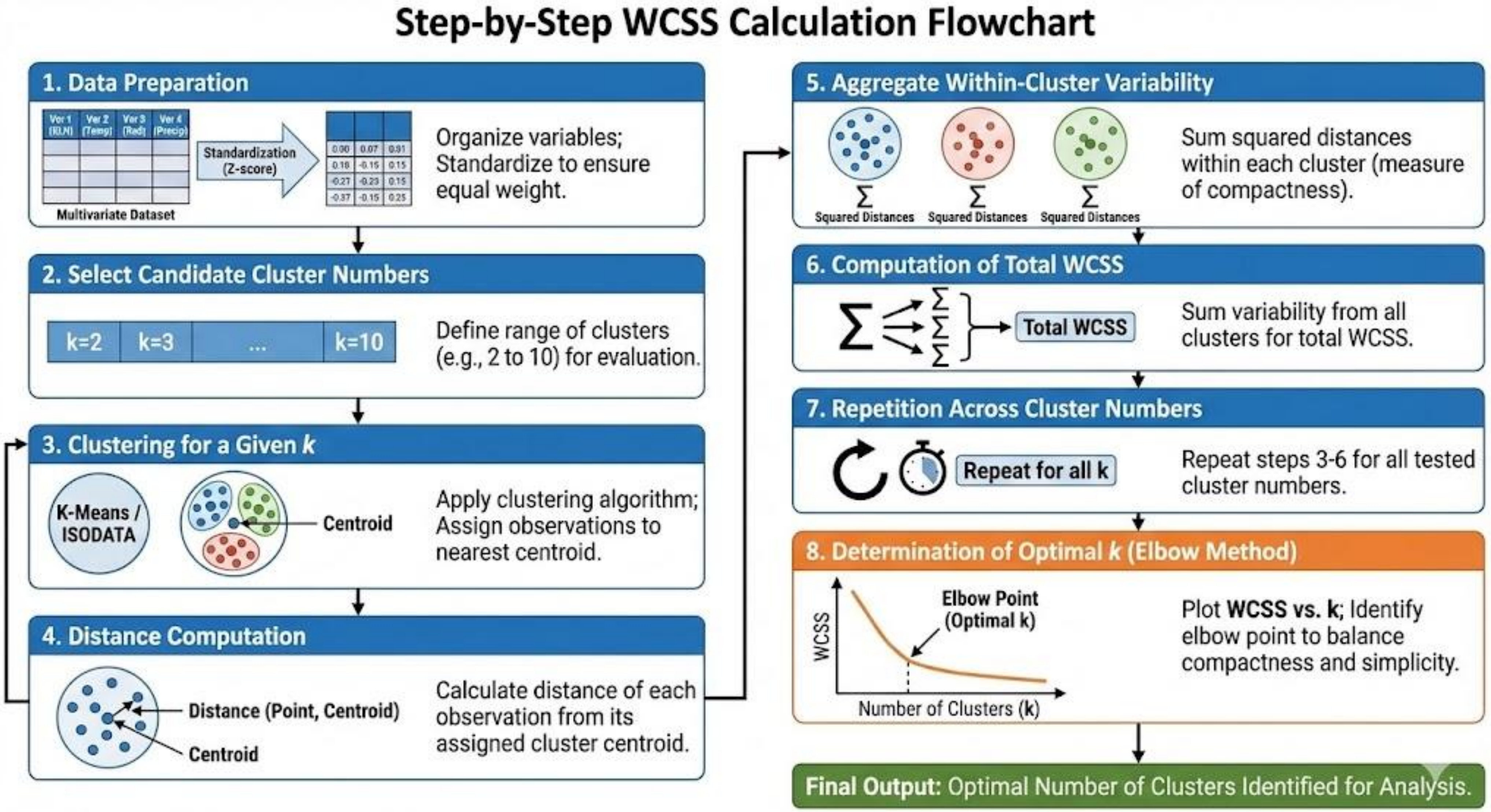
$$WCSS = \sum_{i=1}^{k} \sum_{x \epsilon C_i} \|x_i - \mu_i\|^2$$

Optimal Cluster Selection:

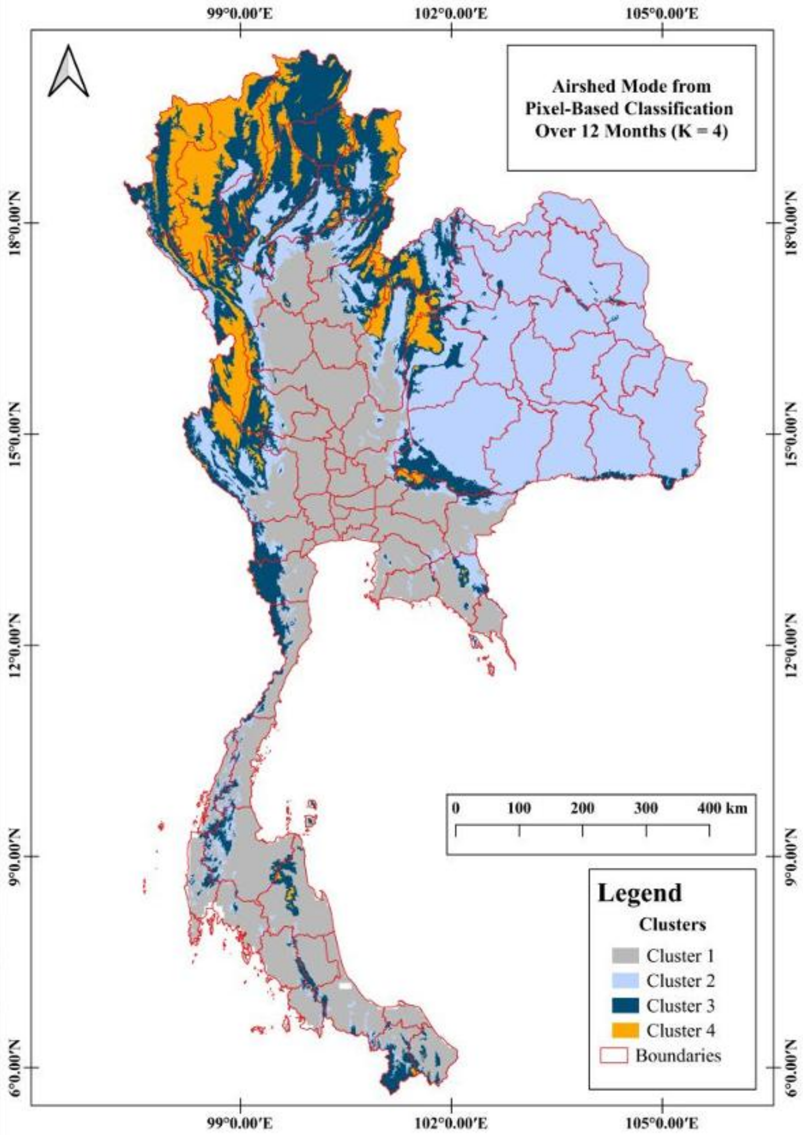
1. The optimal k corresponds to the elbow point
2. In this study: k=4 was identified as optimal for both classification methods



MODEL PROCESSING

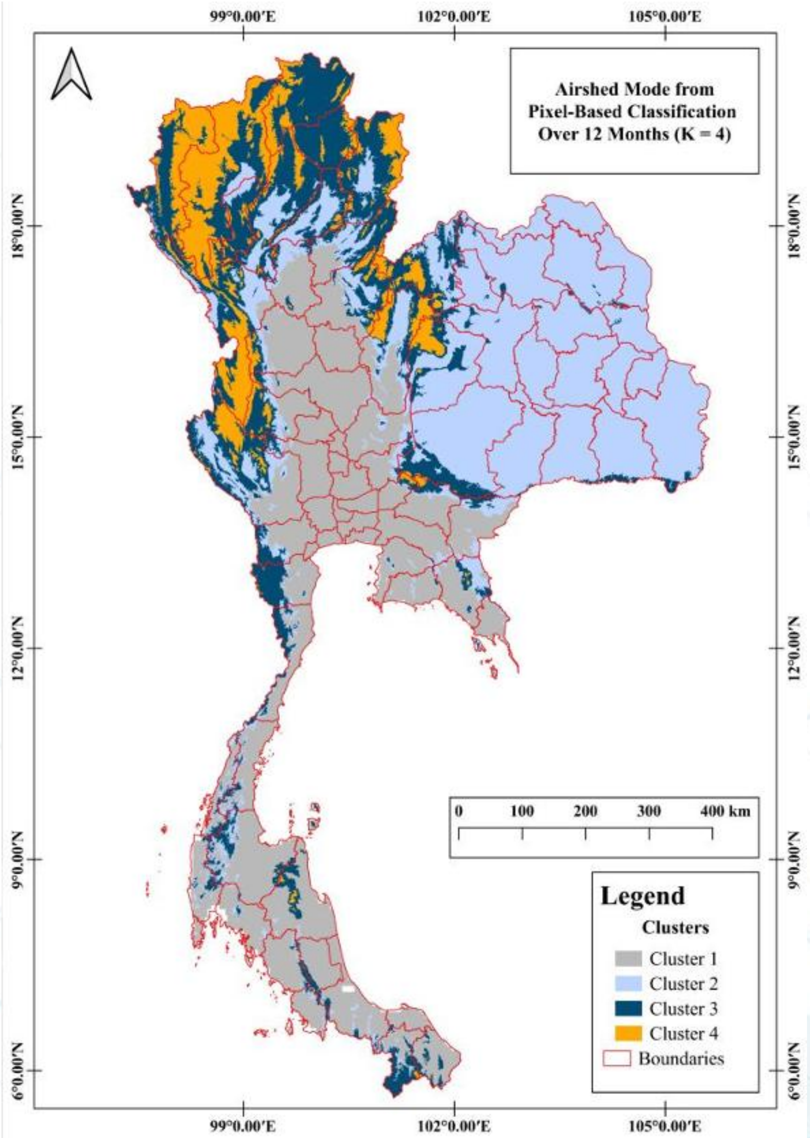


RESULTS



Variable	Cluster 1	Cluster 2	Cluster 3	Cluster 4
DEM (m)	27.89	177.61	435.47	808.94
PBL (m)	556.08	488.48	434.99	427.62
PPT (mm)	174.36	154.87	133.94	113.59
SRAD	218.31	218.96	214.92	211.65
SUR (hPa)	1006.54	988.10	960.09	934.19
TMAX (°C)	32.37	31.84	31.41	30.12
TMIN (°C)	23.80	22.04	20.43	18.73
VAP	2.93	2.62	2.44	2.20
WS (m s^{-1})	1.84	1.41	1.21	1.28

RESULTS

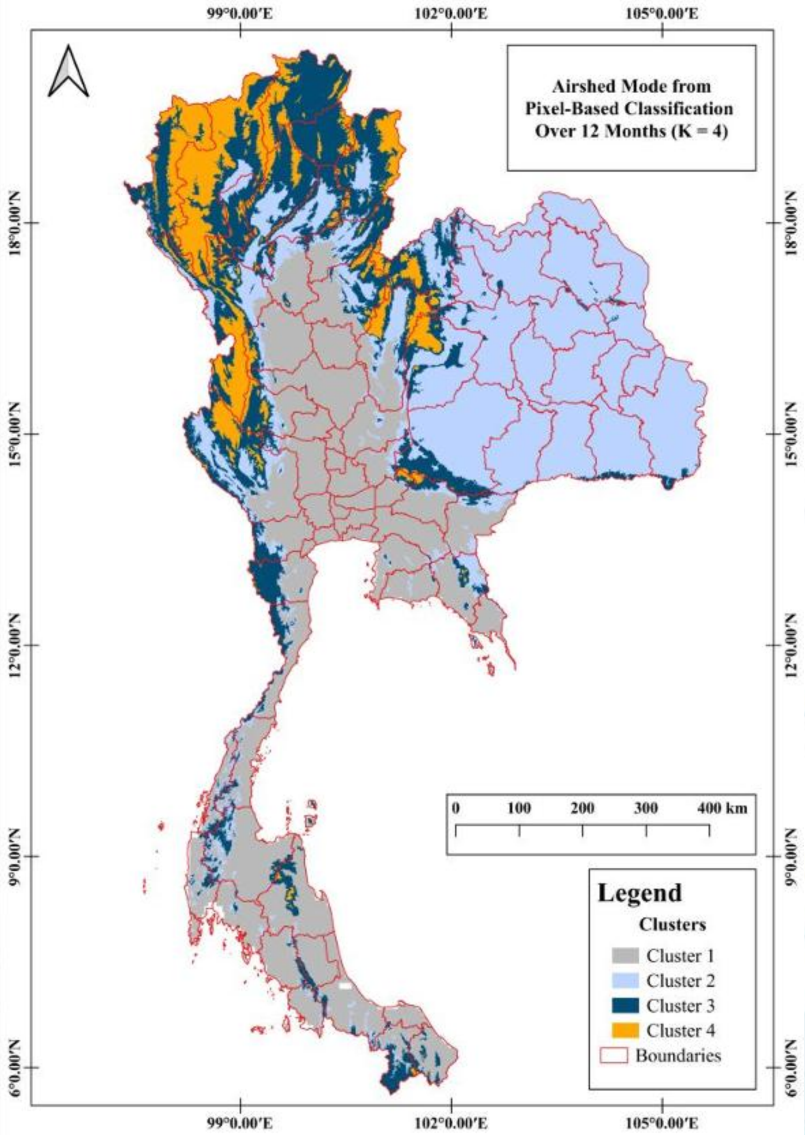


Cluster 1

Areas with low topographic elevation

- Characterized by the **lowest average elevation**, with **high temperature and high relative humidity**.
- Efficient wind circulation promotes **good atmospheric ventilation**.
- As a result, this airshed exhibits the **lowest susceptibility to PM2.5 pollution** among all groups.

RESULTS

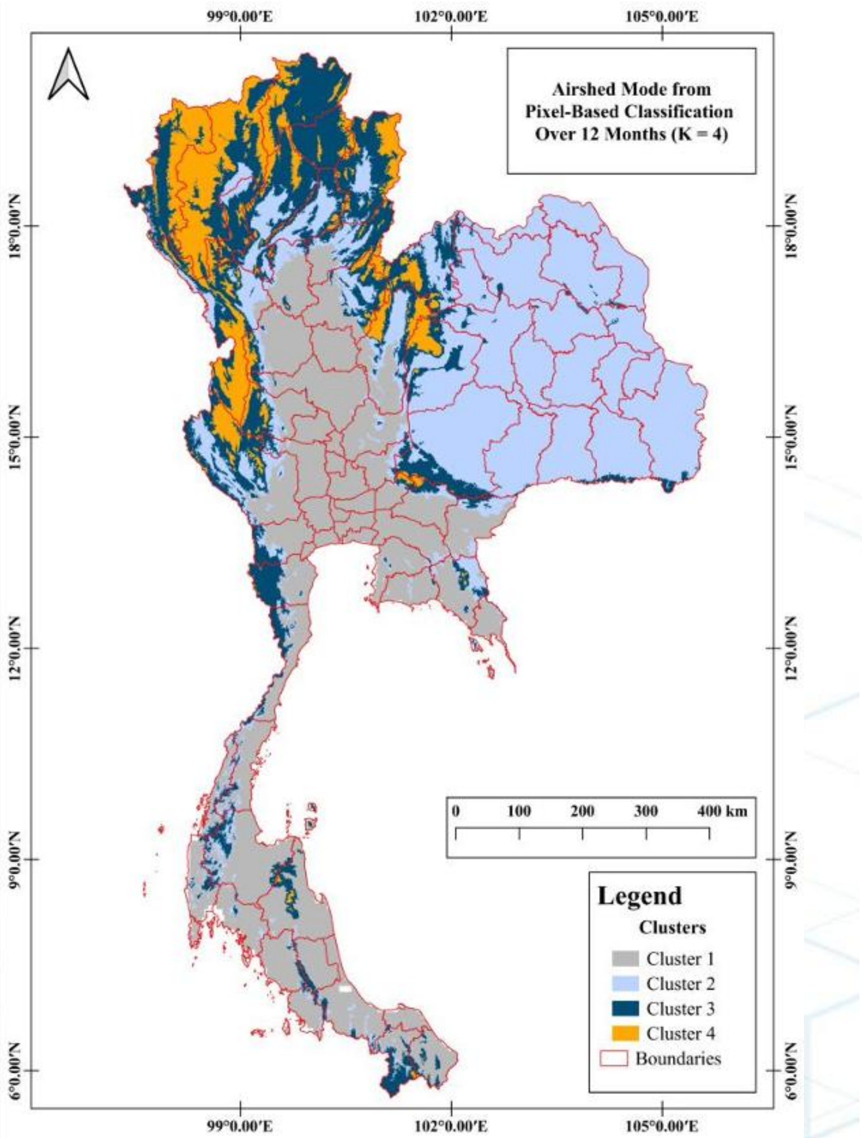


Cluster 2

Regions with flat topography and moderate elevation

- The average topographic elevation corresponds to **flat terrain with moderate elevation.**
- Meteorological variables show a **decreasing trend compared** to Cluster 1.
- This group exhibits a higher susceptibility to PM2.5 impacts when compared to Cluster 1.

RESULTS



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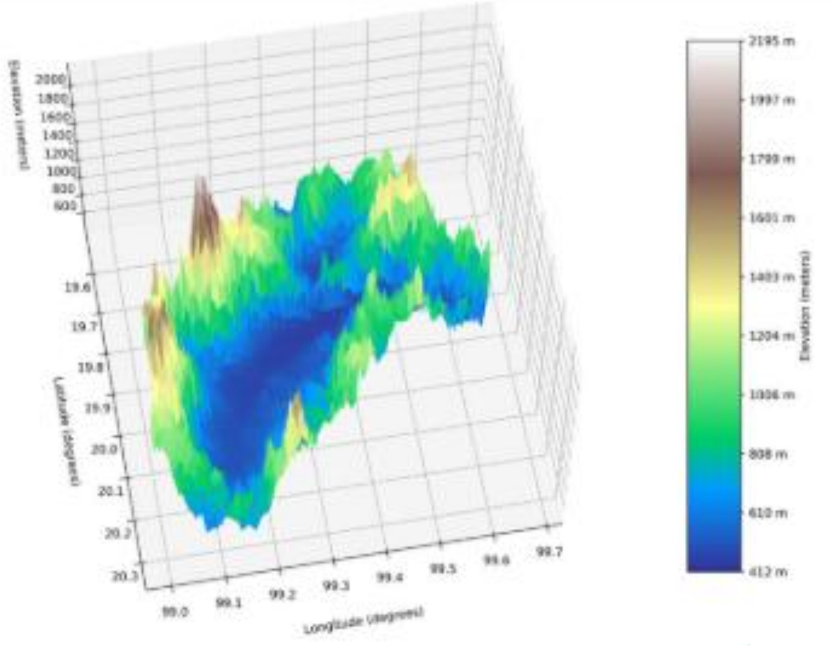
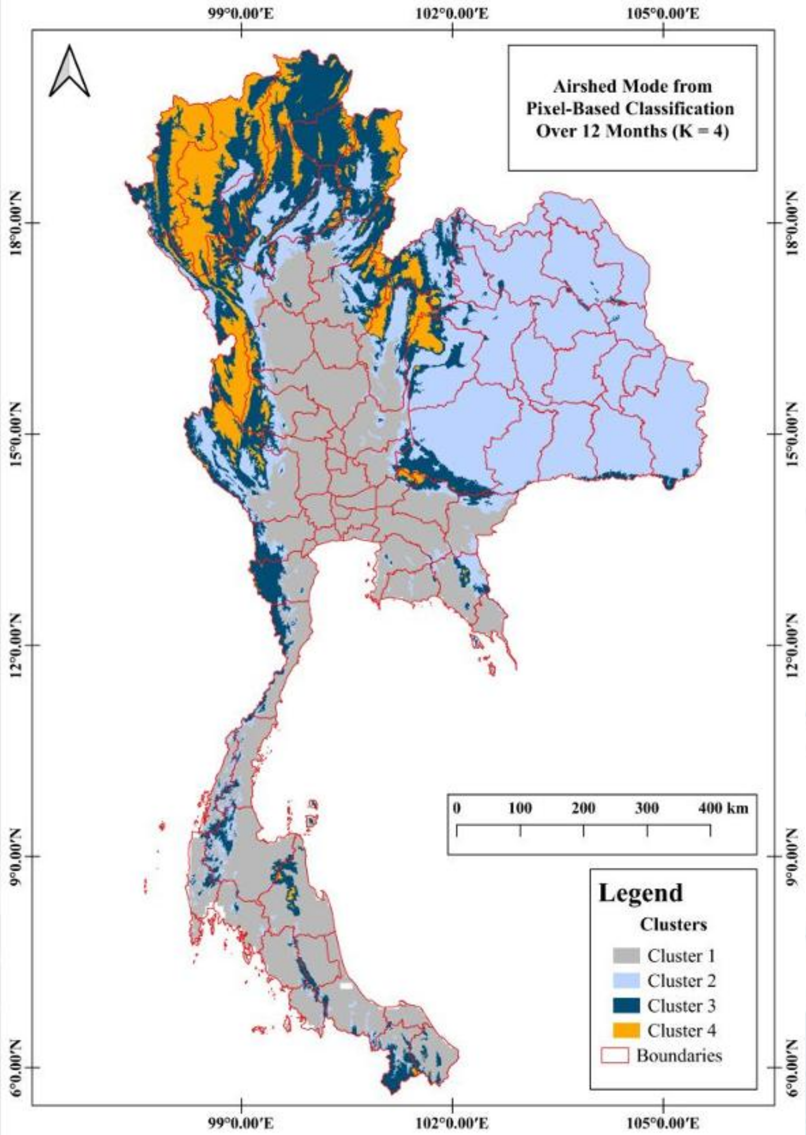


Regions with flat topography and moderate elevation

Note: Several areas in Northern Thailand are classified as Cluster 3 and 4, which are characterized by terrain surrounded by high mountains. This topographic configuration can form basin-like environments, potentially enhancing pollutant accumulation and worsening air quality conditions.

RESULTS

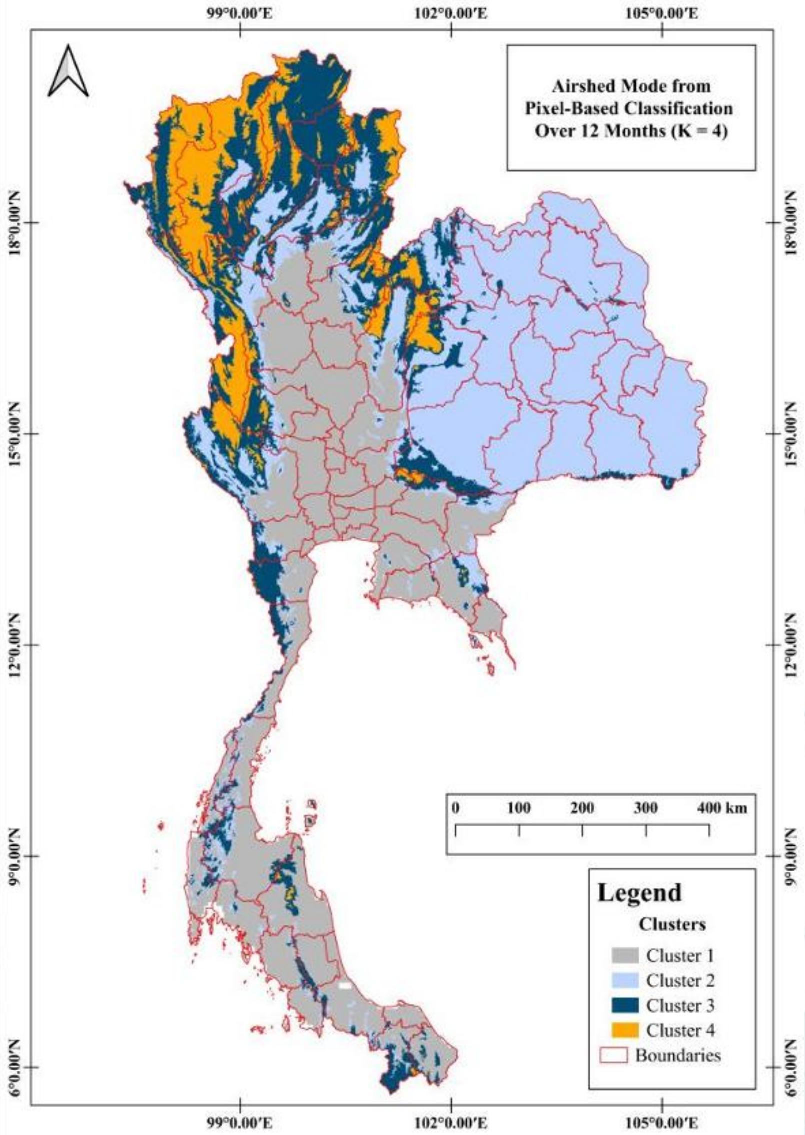


Cluster 3

Areas in this group are characterized by hilly terrain or highland areas.

- The average topographic elevation is higher than that of Cluster 1 and 2.
- Mean climatic variables across all factors show a **declining trend compared** to Cluster 1 and 2.
- This group exhibits a clearly higher susceptibility to PM2.5 impacts than Cluster 1 and 2, which is closely associated with the increasing topographic elevation.

RESULTS

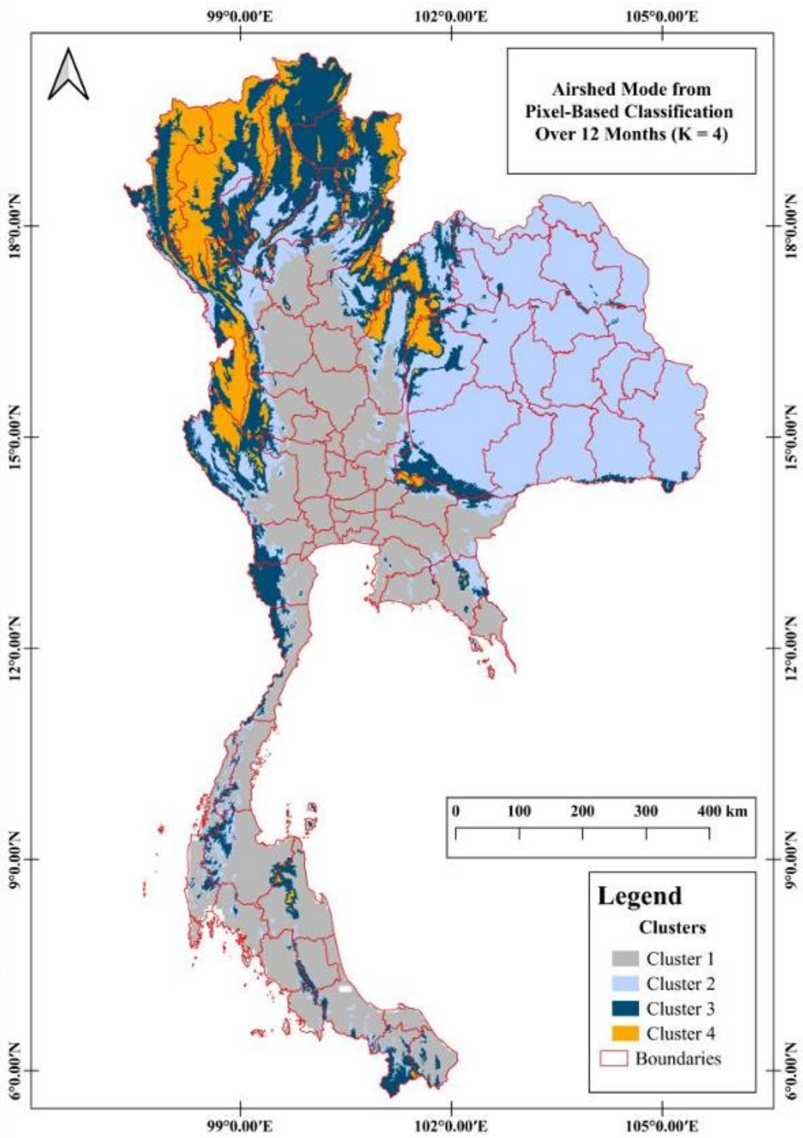


Cluster 4

Areas in this group are characterized by high mountainous terrain.

- The average topographic elevation is the highest among all four groups.
- Climatic variables across all factors are at the lowest levels.
- This group exhibits the highest susceptibility to PM2.5 impacts, reflecting a clear relationship between topographic elevation and meteorological factors.

RESULTS



Month	Cluster 1	Cluster 2	Cluster 3	Cluster 4
PM2.5 March	33.16	49.23	65.24	68.45
PM2.5 April	25.63	35.21	48.06	52.58

- Additional conditions may be required, particularly the inclusion of qualitative criteria. This is because several areas in Northern Thailand are classified as Cluster 2, while their surrounding terrain is dominated by high mountainous regions (Cluster 3 and 4).
- Such topographic settings can create basin-like environments, where air circulation is restricted. Consequently, these areas may experience PM2.5 impacts influenced by Cluster 3 and 4, despite being classified as Cluster 2 based on quantitative indicators.

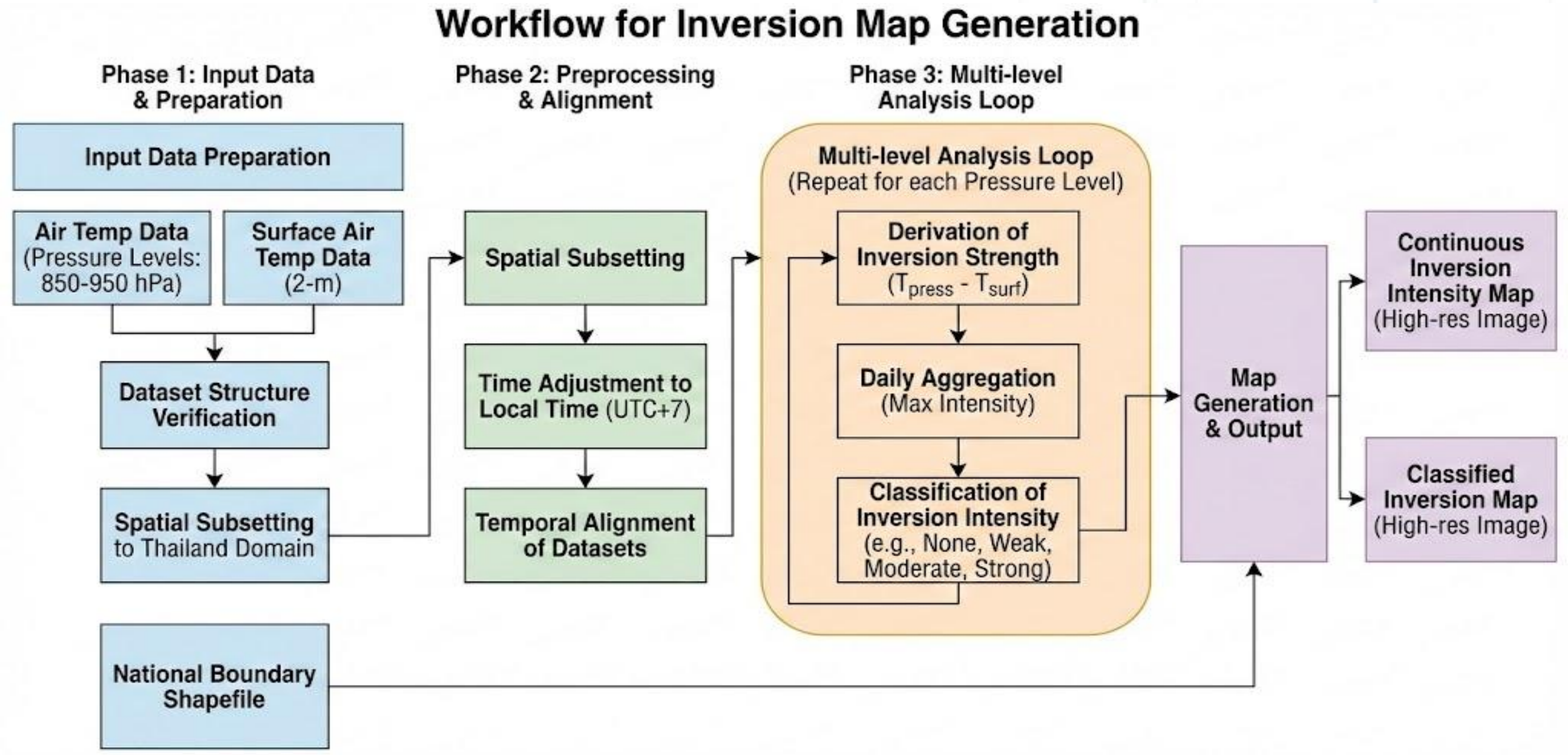
REMARK

- The analysis is based on **21-year monthly meteorological data** combined with static topographical features, which may **not fully capture short-term atmospheric** variability.'

- The use of monthly aggregated data limits the ability to represent sub-monthly or daily dynamics, particularly during **extreme pollution episodes** or transient meteorological conditions.

- The current airshed delineation is therefore not fully dynamic, as it does not explicitly account for temporal changes in wind patterns, boundary layer evolution, or **inversion events**.

FUTURE PROCESSING



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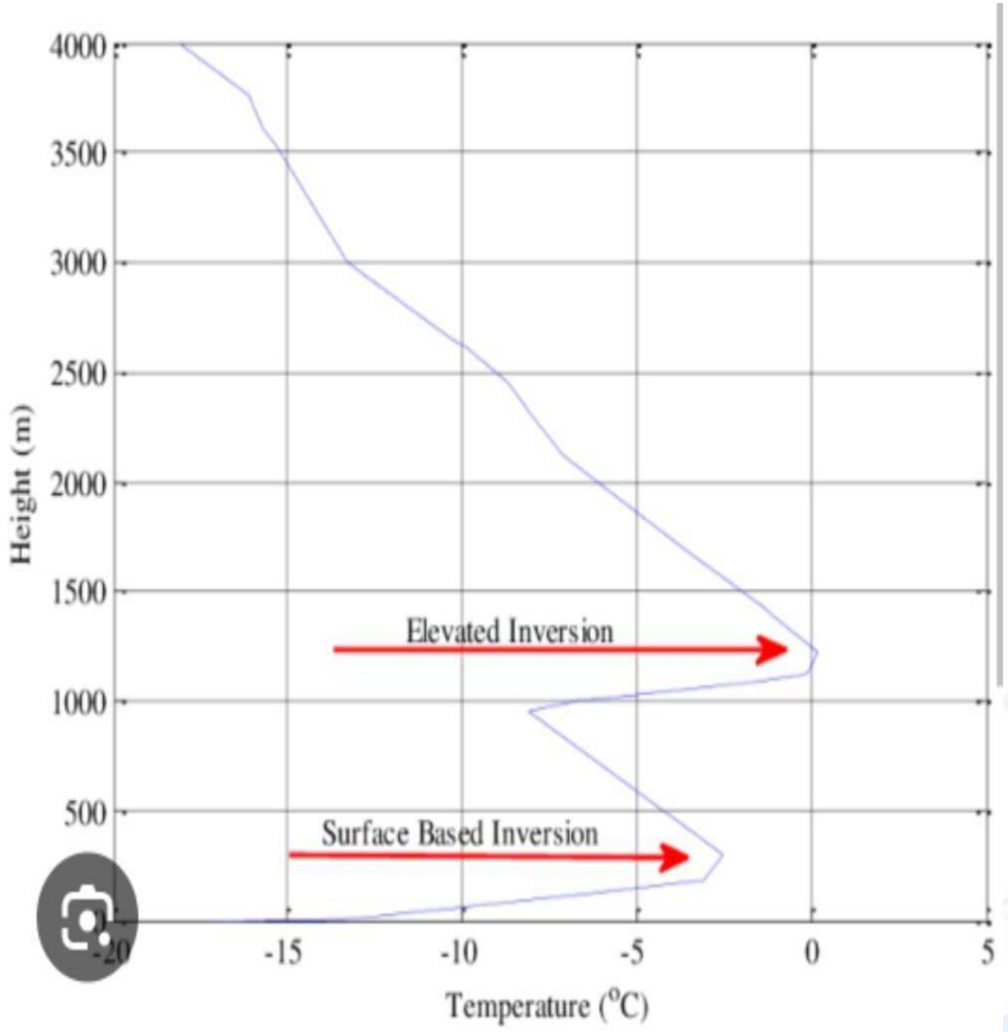
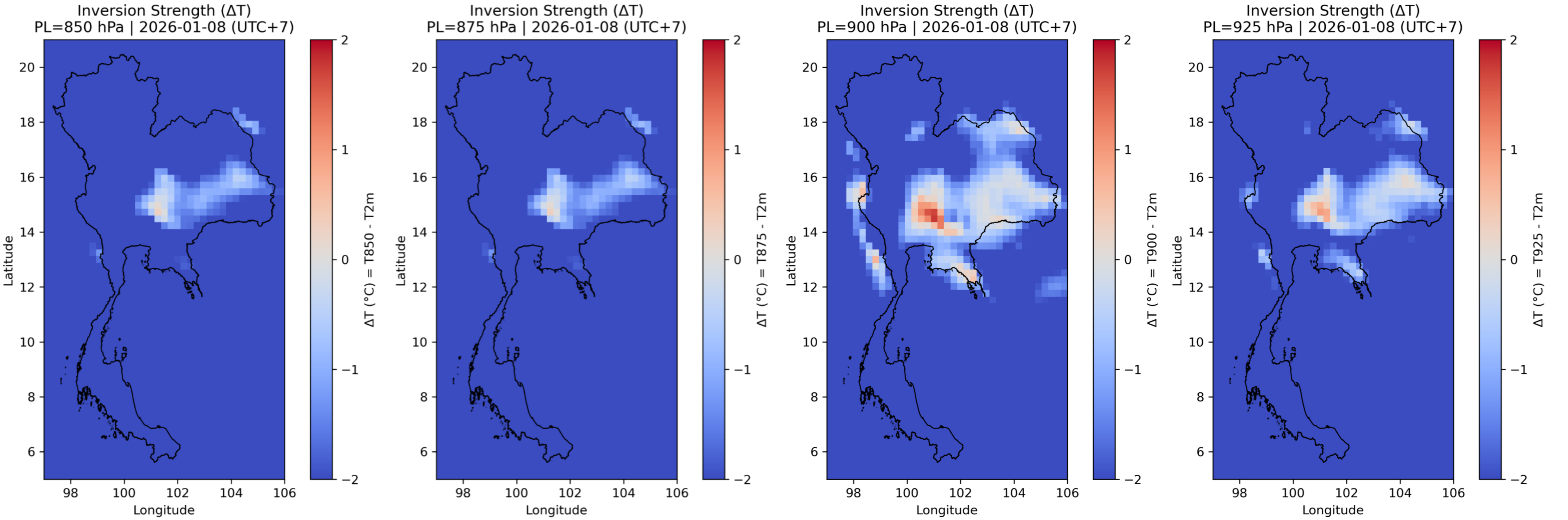


- The 900–850 hPa levels represent the lower troposphere, where elevated temperature inversions commonly occur and directly influence near-surface air quality.
- These levels typically correspond to altitudes around 900–1,300 m, matching the inversion layers observed in the vertical temperature profile.
- Inversions at 900–850 hPa act as a capping layer that suppresses vertical mixing, thereby enhancing PM2.5 accumulation near the surface.

FUTURE PROCESSING



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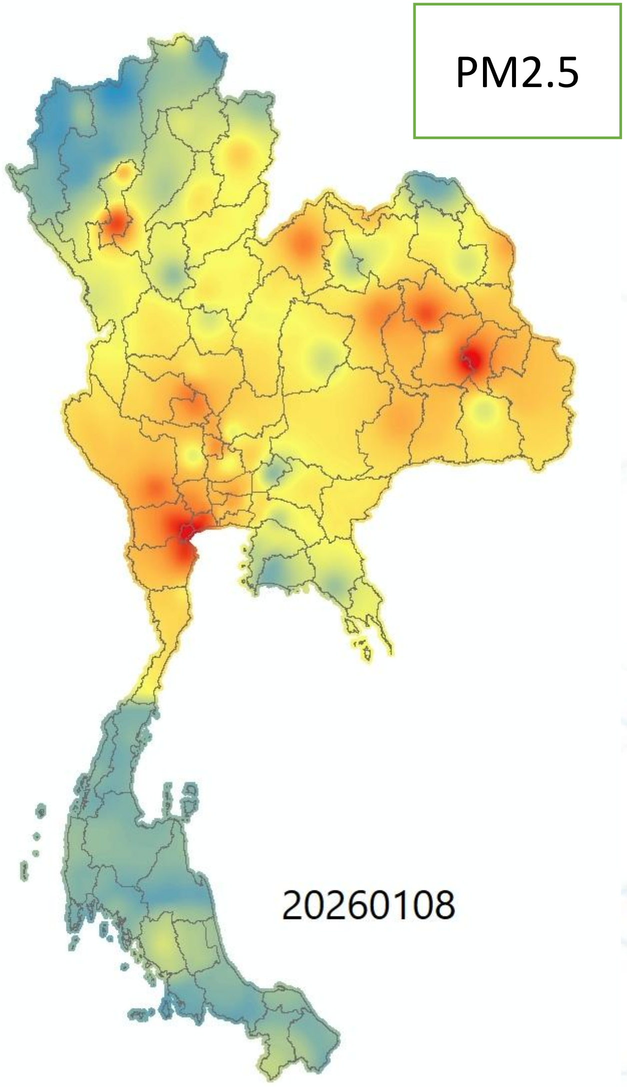

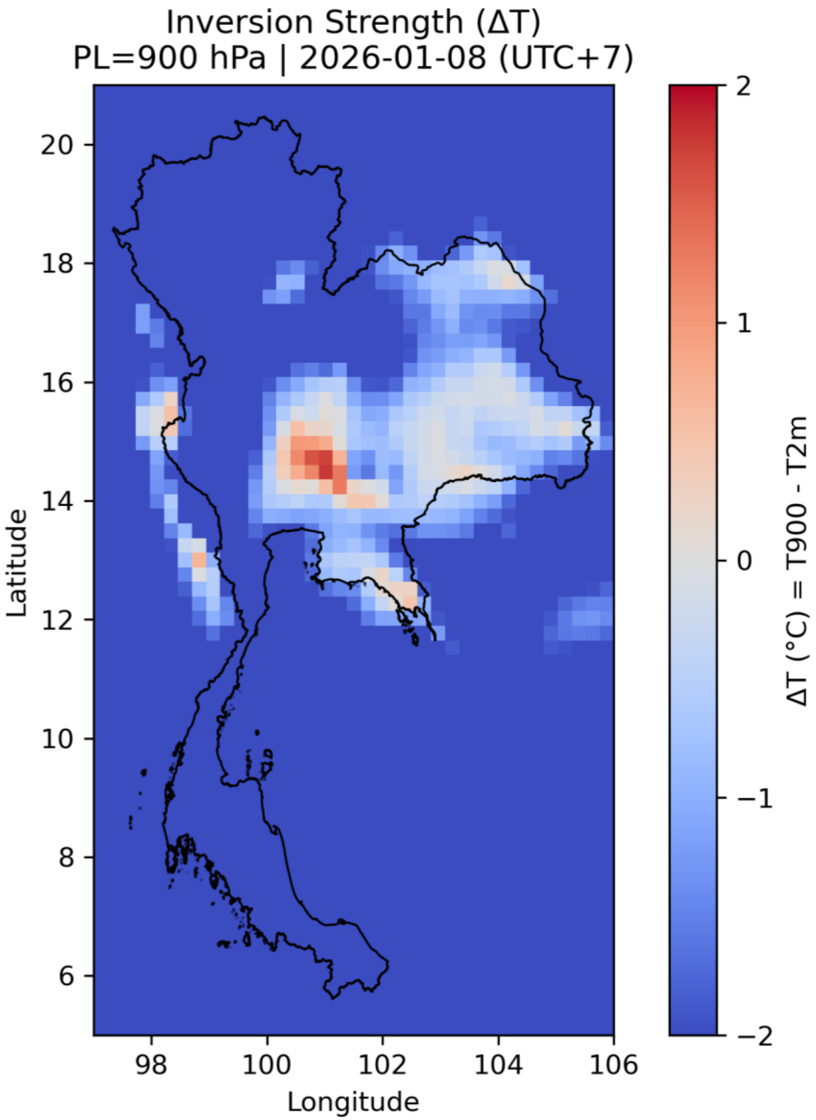

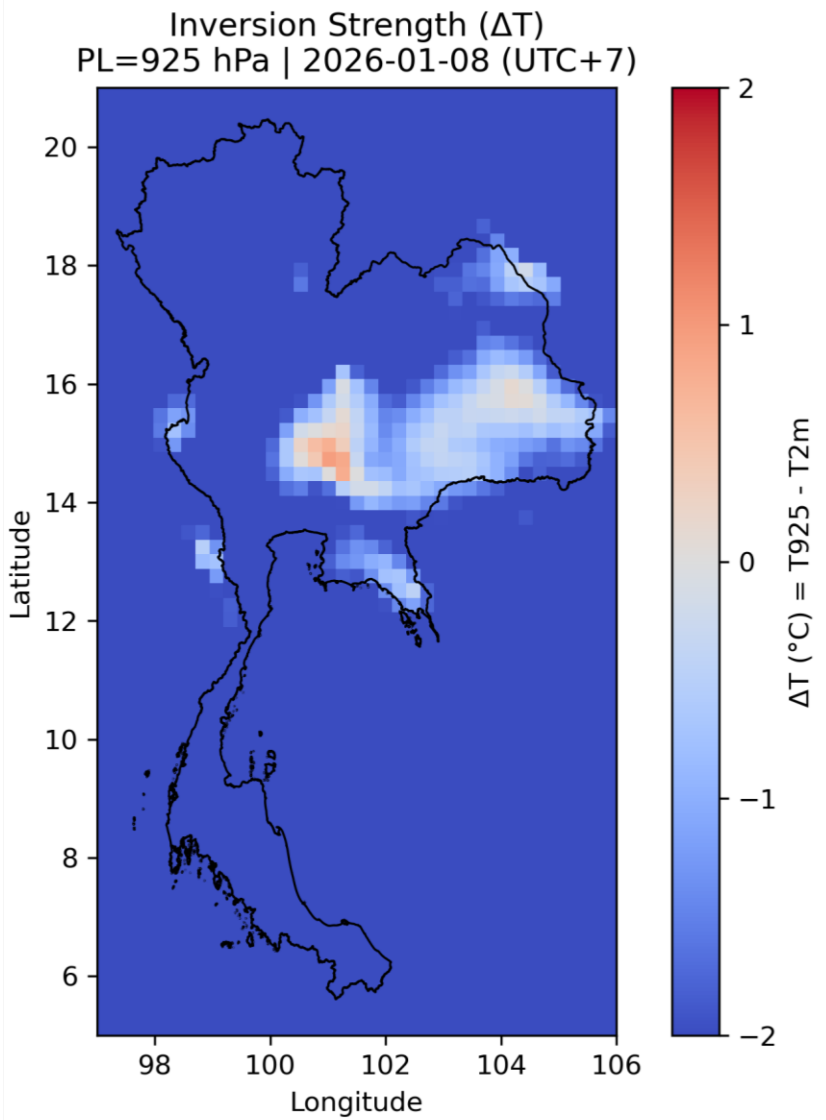

GISTDA

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