International Workshop on
Land Use/Cover Changes and Air Pollution in Asia

Air Pollution Management System in Vietnam

1

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PHAN VAN THANH, DO XUAN TU

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Bogor, Indonesia - August 4th – 7 th, 2015

Outline

- Introduction
- Objectives and Approaches
- PM Concentration Mapping
- Air Pollution Management System
- Conclusion

Outline

- **Introduction**
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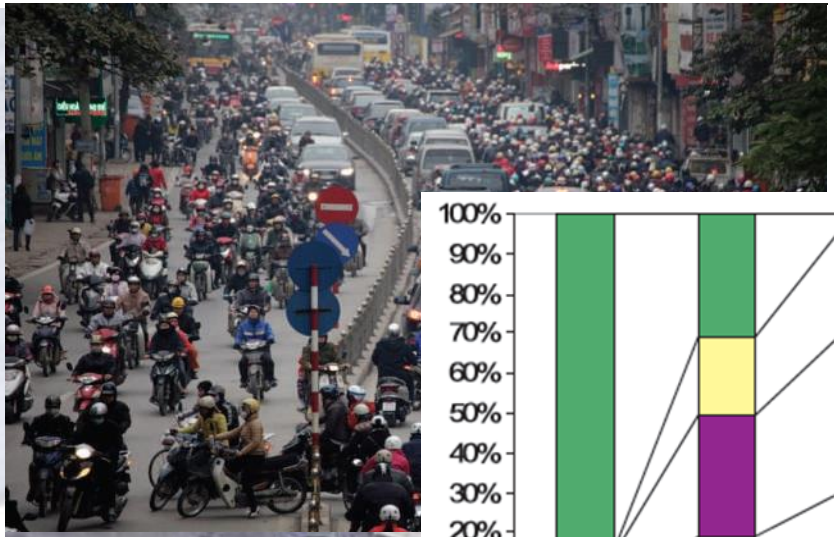
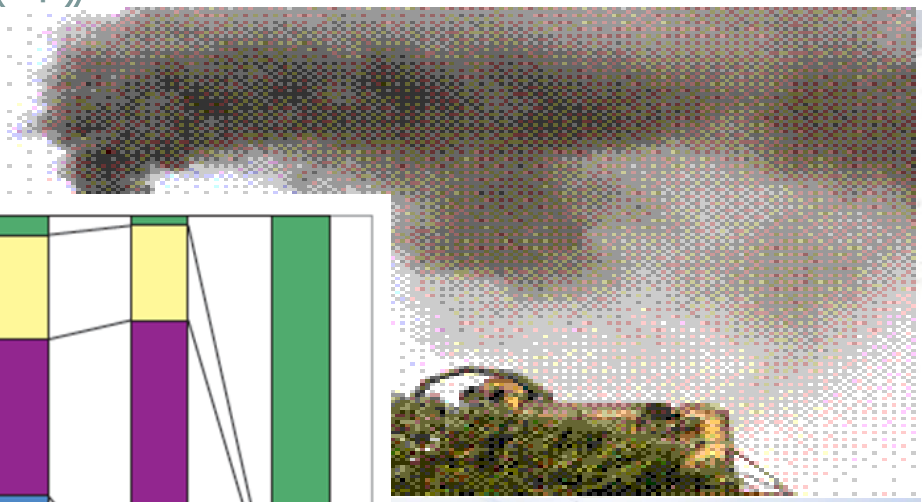
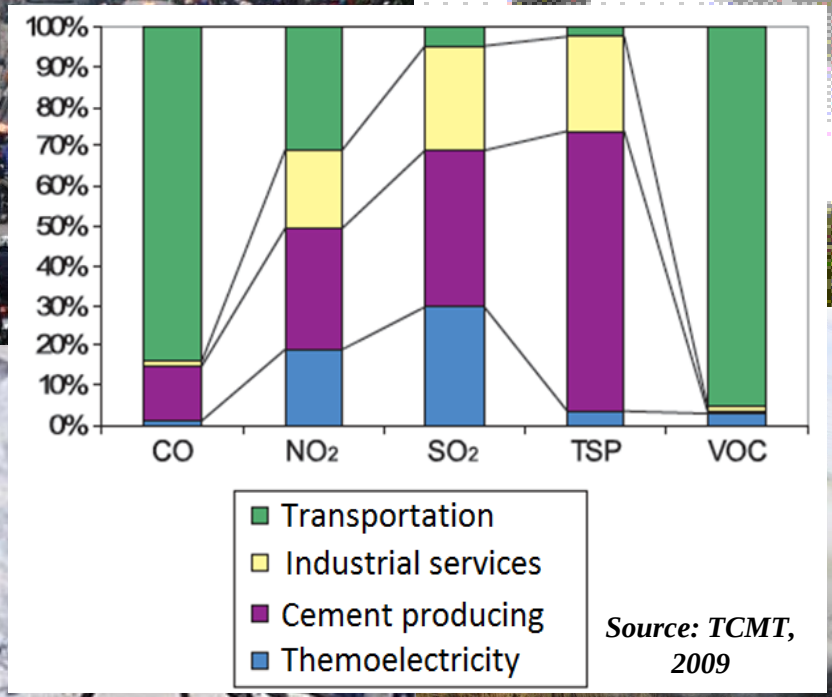
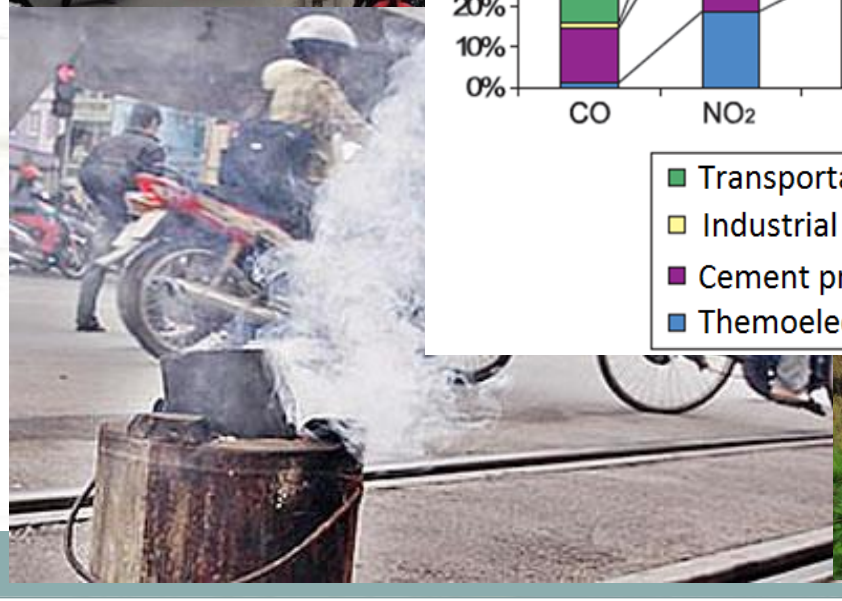
Air pollution in Vietnam

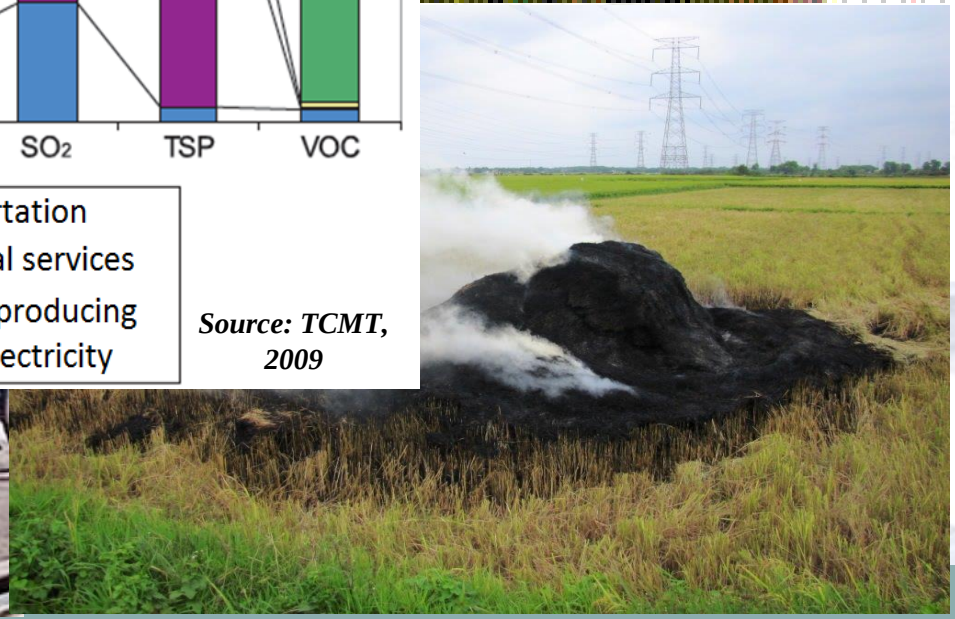






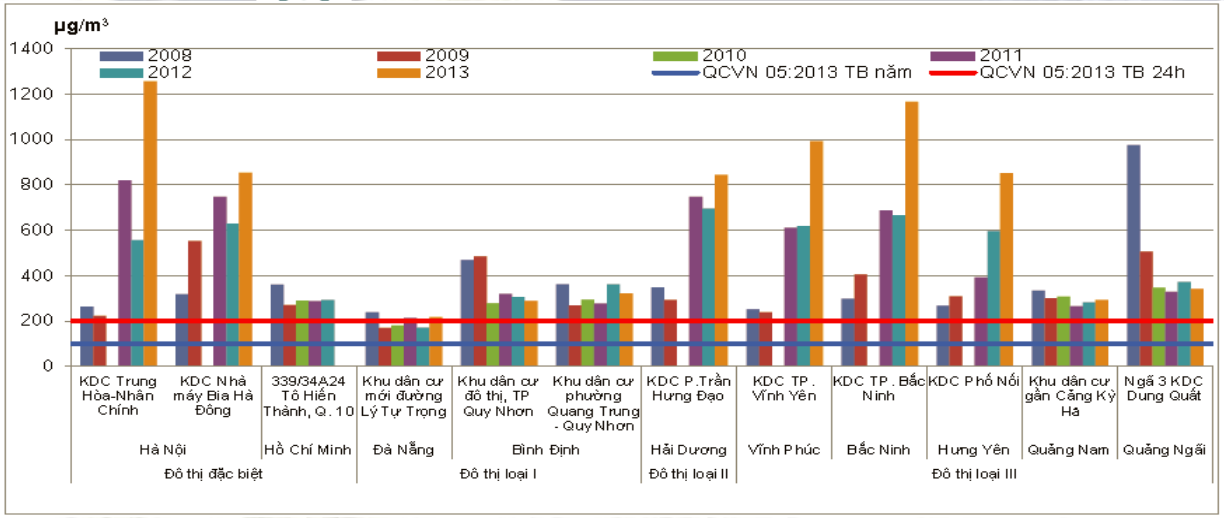
Source: TCMT, 2009

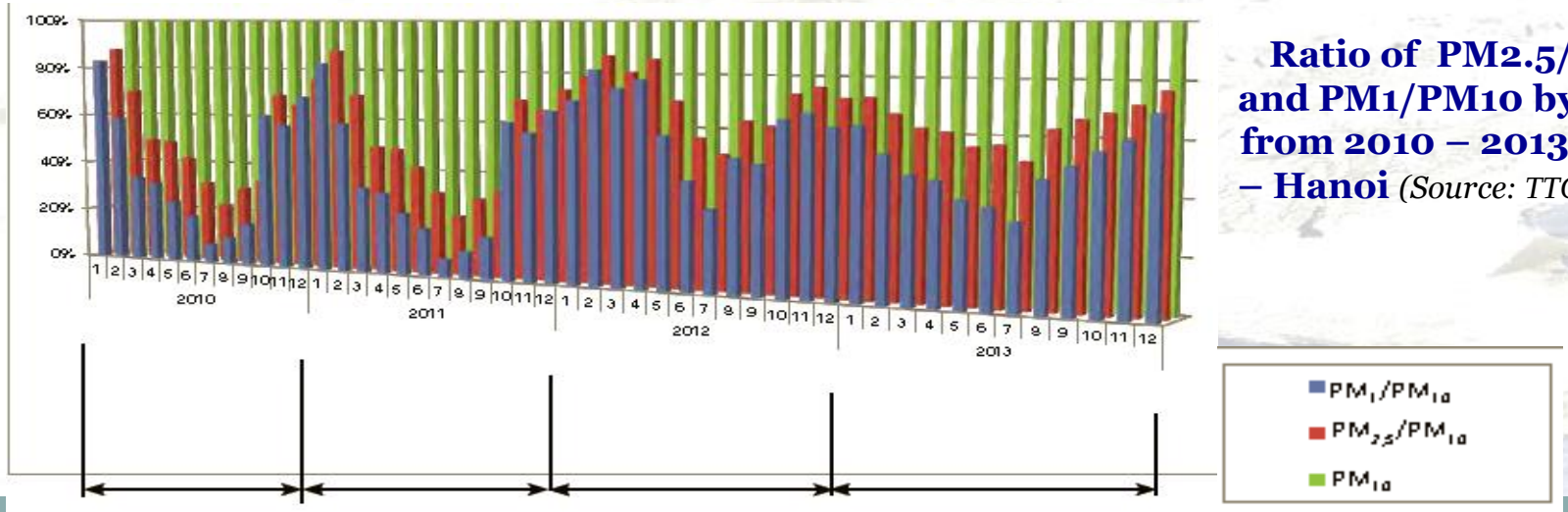




Air pollution in Vietnam

Yearly TSP at cities in Vietnam from 2008 to 2013
(Source: TCMT, 2013)

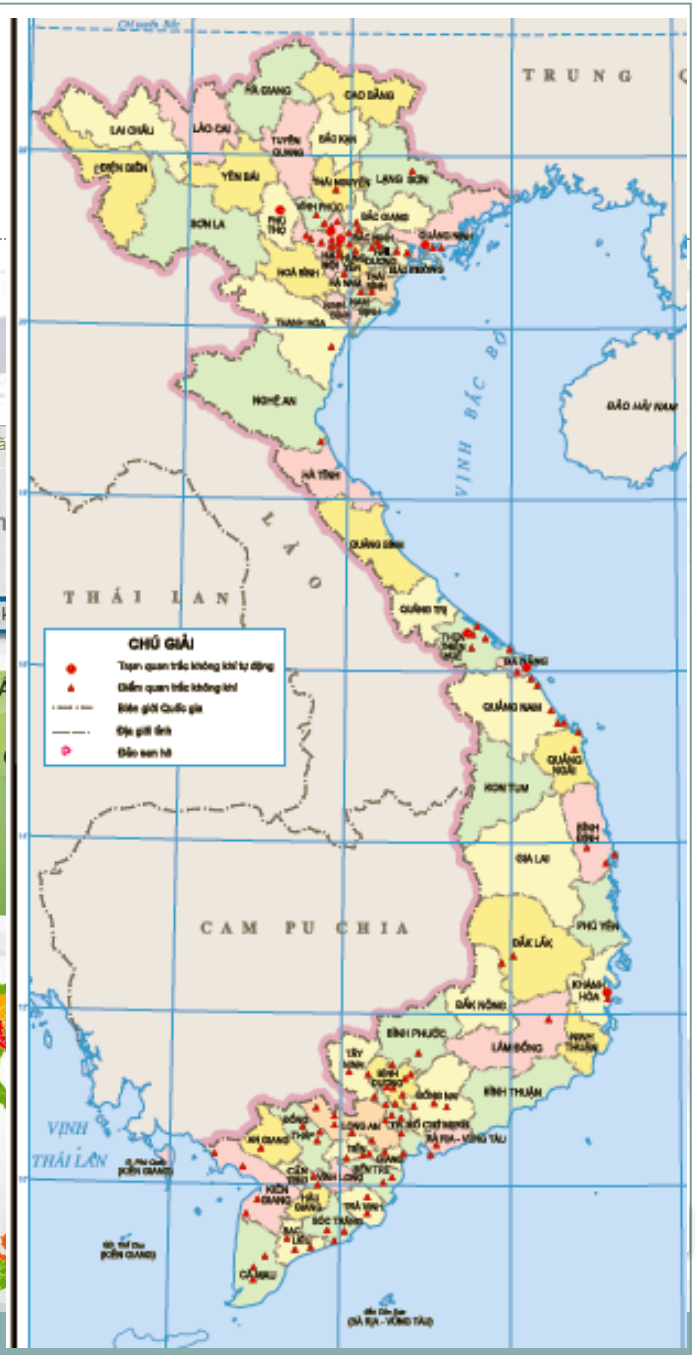




Ratio of PM2.5/PM10 and PM1/PM10 by month from 2010 – 2013 at NVC – Hanoi *(Source: TTCMT, 2013)*

Air pollution in Vietnam

- Center of Environment Monitoring, VEA. National center for Hydro-Meteorological Forecasting (NCHMF), MONRE
- City Dept. of Natural Resource and Environment

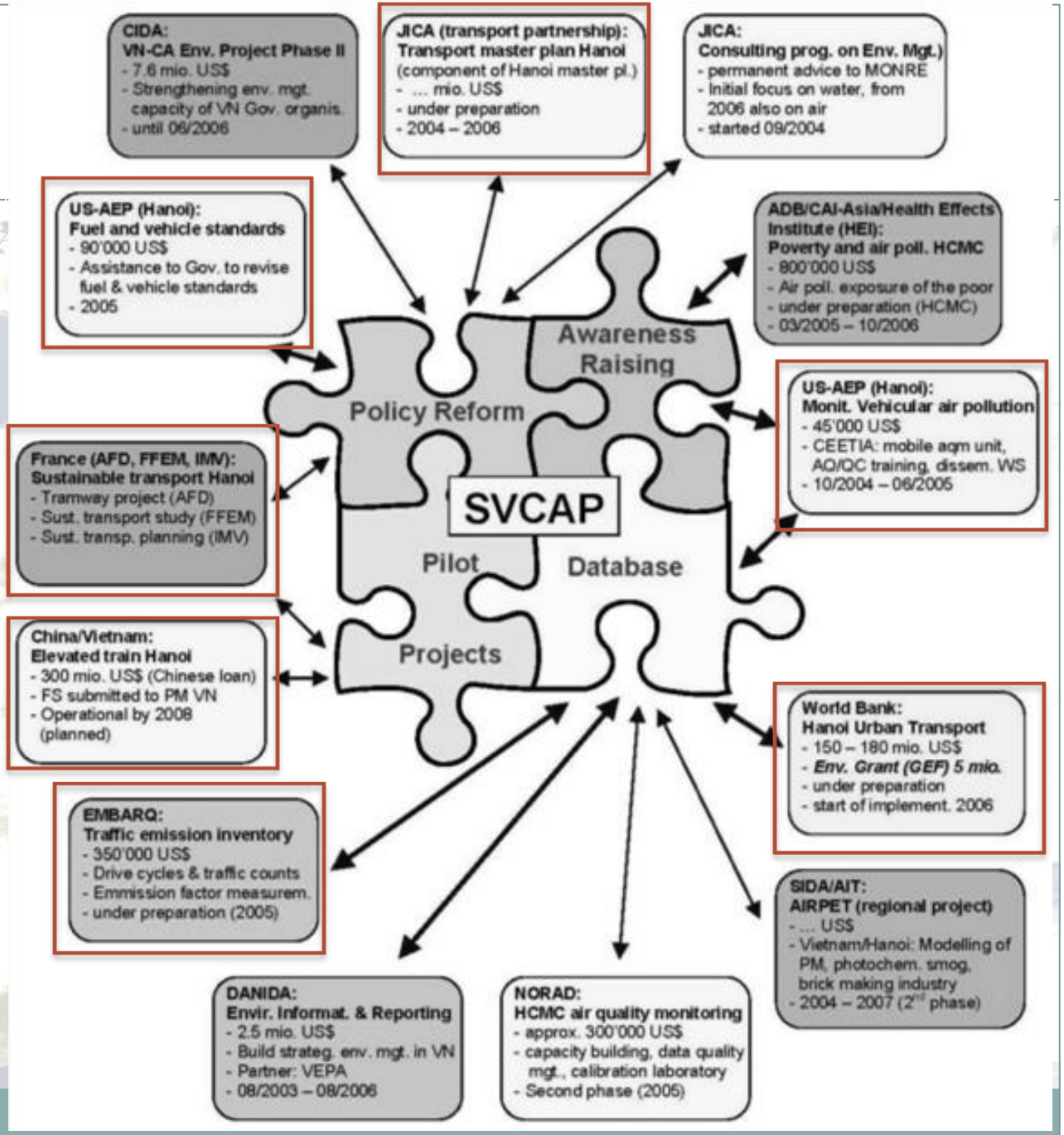


Air pollution in Vietnam

Air quality management projects in Vietnam

(Source: Ngo Tho Hung, 2010)

- **Air pollution is serious in Vietnam**
- **Lack of measurements and closed information**
- **Lack of online monitoring and warning systems**
- **Satellite application for air management is initially investigated**



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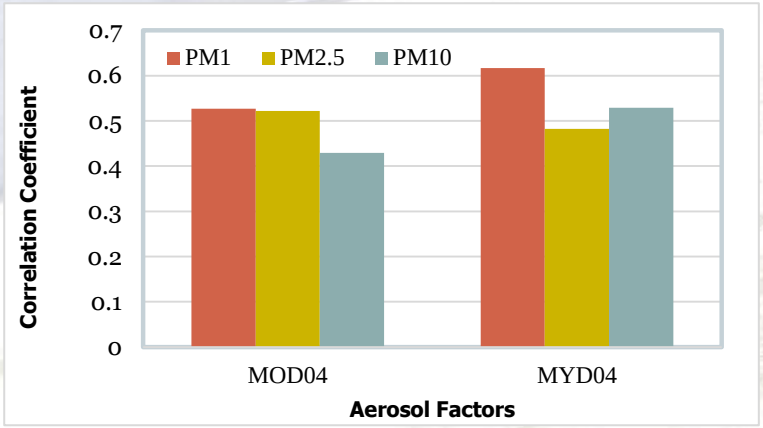
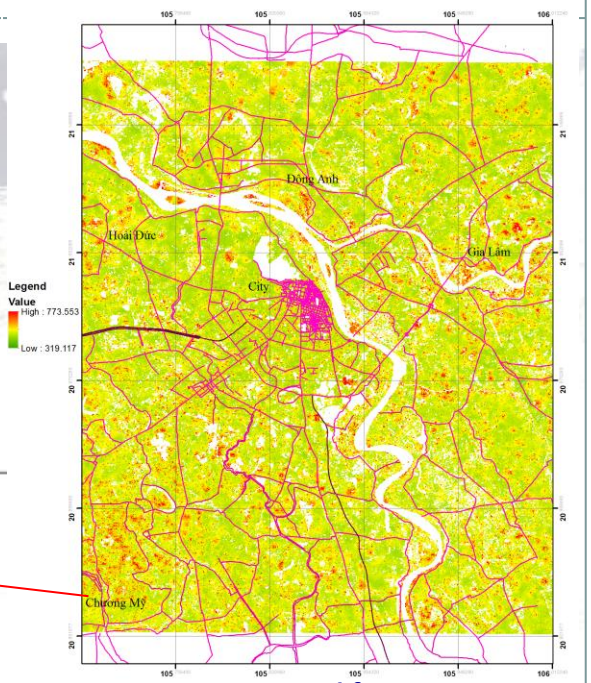
Research Objective and Approach

- Monitor PM based on satellite images

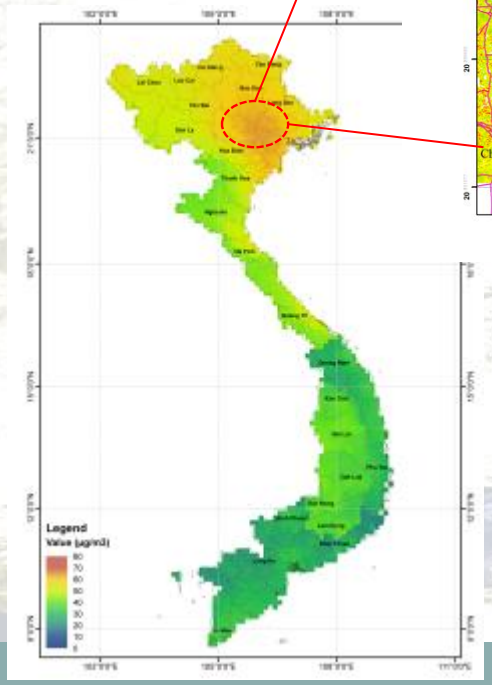
MODIS AOT vs. PM Correlation at
PhuTho, Hanoi, Hue, DaNang, 2010-2014





PM10 estimated from SPOT4 at May 4, 2012

- Provide products at different spatial and temporal scales



PM2.5 Estimation from MODIS in Jan 24th, 2014

Research Objective and Approach

Data

Modelling

Services

Data Collect/Pre-Process/ Management

PM2.5 Estimation from MODIS/VIIRS

AQI calculation

Monitoring

Search & Download

Report

Warning

VNU UET Ground Station

Manager, Experts, Citizen

Air Pollution Management System

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Vietnam

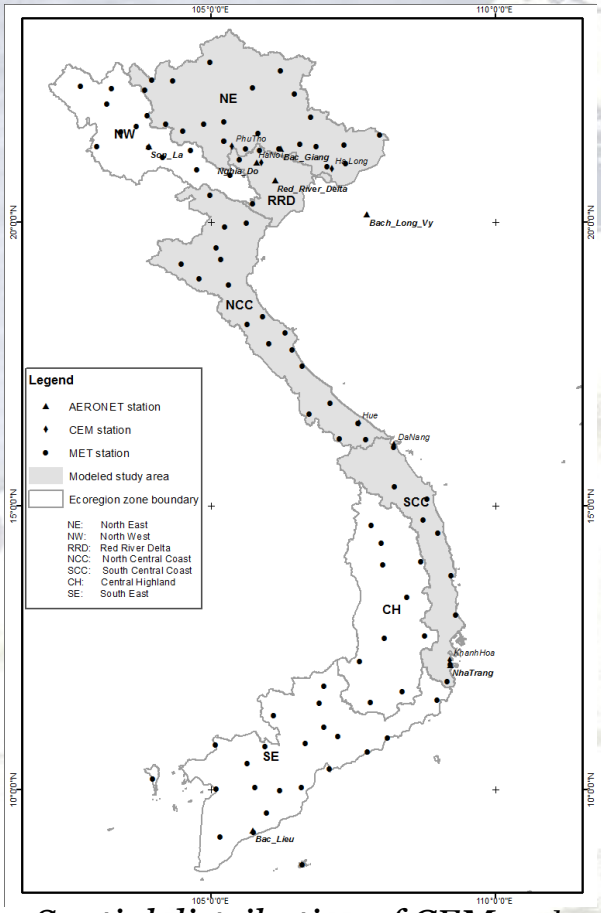
12

MODIS PM2.5 10X10 KM*

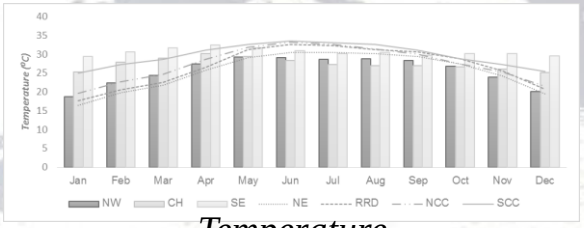
NPP PM2.5 6X6 KM

** Nguyen et al., "Particulate Matter Concentration Mapping from MODIS Satellite Data: A Vietnamese Case Study", 2015, ERL, In Press.*

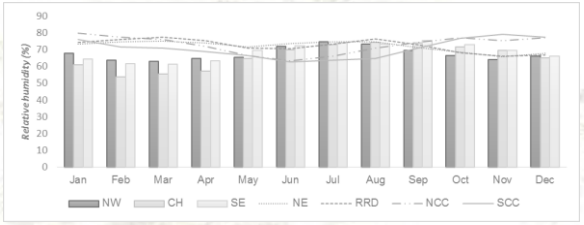
Study Area



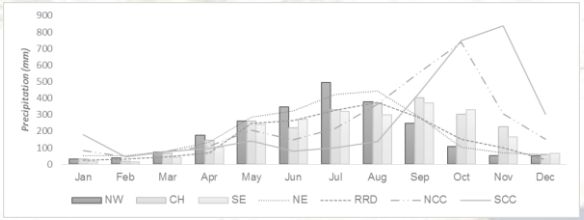
Spatial distribution of CEM and AERONET stations, NCHMF meteorology stations



Temperature



Relative Humidity



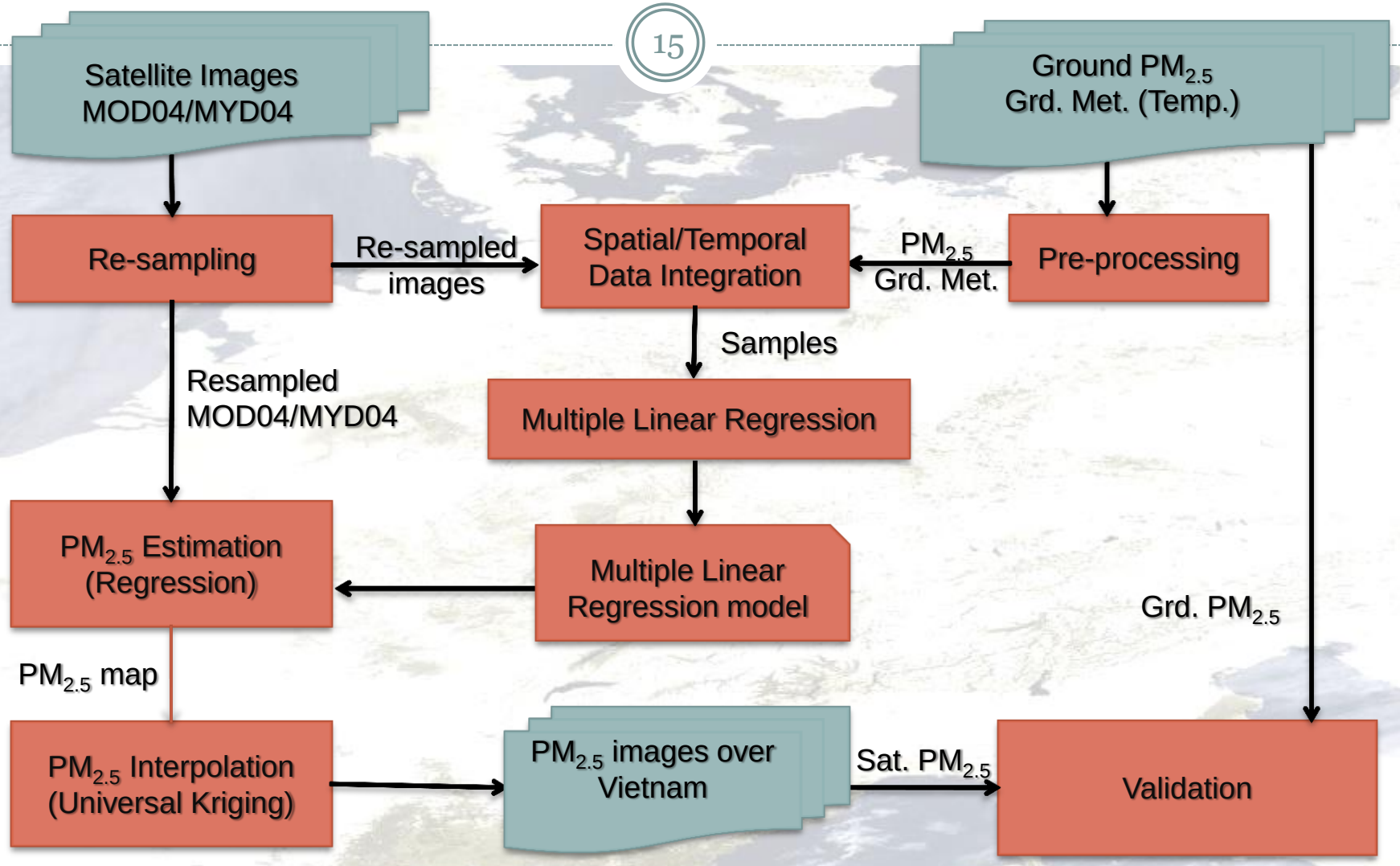
Principitation

- Vietnam is nearly 332,210 km^2 and extends from (8°N, 102°E) to (23°N, 120°E) with the population of 90.5 million as of 2014.
- 7 climatology regions (NW, **NE, RRD, NCC, SCC**, CH and SE)

Datasets

Types	Data	Description	Start	End	Purpose of use
Sat.	MOD04	Terra, Aerosol, 10x10 km	01/2009	09/2014	MODELING, INPUT FOR EACH PM MAP
	MYD04	Aqua, Aerosol, 10x10 km	01/2009	09/2014	MODELING, INPUT FOR EACH PM MAP
	MOD07	Terra, Meteorology, 5x5km	01/2009	09/2014	MODELING, INPUT FOR EACH PM MAP
	MYD07	Terra, Meteorology, 5x5km	01/2009	09/2014	MODELING, INPUT FOR EACH PM MAP
Insitu	PM2.5	CEM – VEA **PT**, **HL** - NW **HN** – RRD **H** – NCC, **DN, KH** – SCC	12/2010	12/2014	MODELING (PT, HN, H, DN) Ind. VALIDATION (HL, KH)
	Temp, RH, RF	NCHMF, 98 stations	1/2004	2/2014	MODELING
	AOT	AERONET, 7 stations	3/2013	6/2013	VALIDATION

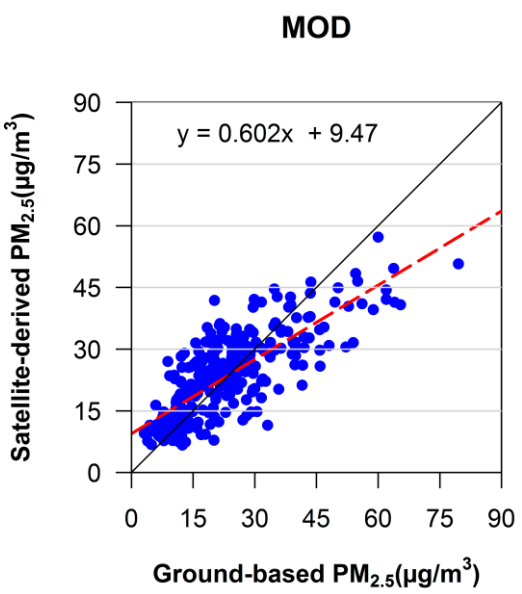
Methodology

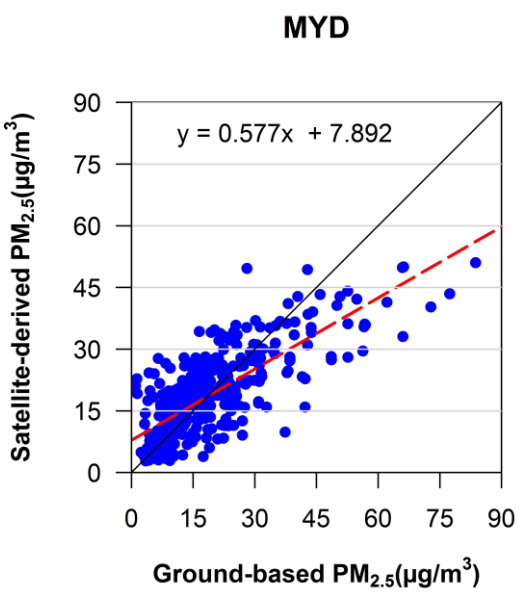


Model Evaluation

$$PM2.5_{t-MOD} = \mathrm{f}(AOT_{t-MOD}, Temp_{mr})$$
$$PM2.5_{t-MYD} = \mathrm{f}(AOT_{t-MYD}, Temp_{mr})$$

MOD				MYD			
#Sample	r^2	RMSE (μg/m³)	RE (%)	#Sample	r^2	RMSE (μg/m³)	RE (%)
274	0.602	8.527	33.348	385	0.577	8.777	53.353





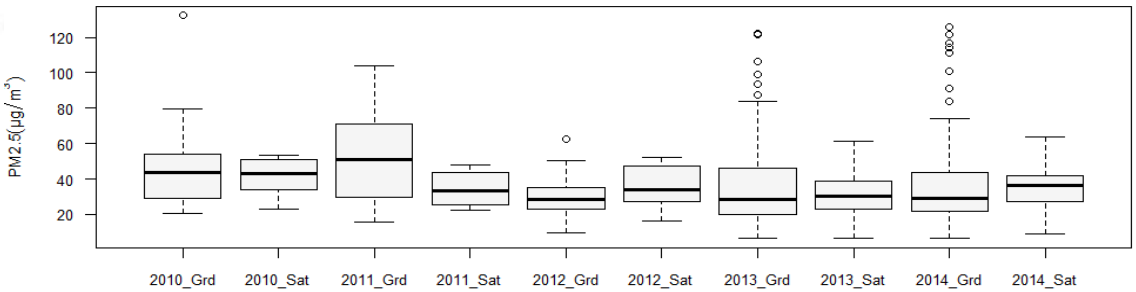
Validation

1. Overall assessment

(Boylan and Russell 2006)
- Mean Fractional Bias (MFB ≤± 30% goal: ≤± 60% - criteria)
- Mean Fractional Error (MFE ≤± 50% goal: ≤± 75% - criteria)

	#Images	#Samples	r^2	RMSE (µg/m3)	RE (%)	MFB (%)	MFE (%)
MOD	85	189	0.427	21.709	39.957	0.491	34.954
MYD	43	96	0.337	17.188	39.458	3.639	34.799
Total	128	285	0.411	20.299	39.789	1.552	34.902

Overall validation of satellite-derived $PM_{2.5}$ maps over Phu Tho, Ha Noi, Hue and Da Nang in NE, RRD, NCC and SCC regions, respectively. Results are separated by MOD and MYD datasets and accumulated in total.



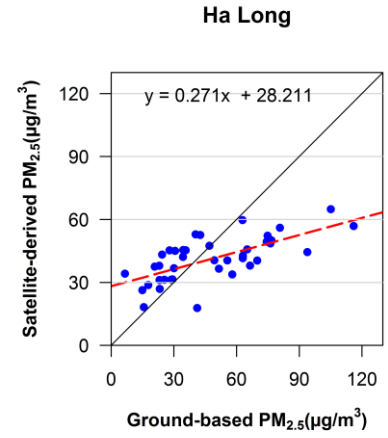
Boxplots shows the variation of satellite derived PM2.5 (_Sat) and ground based PM2.5 (_Grd) from 2010 – 2014 at Phu Tho, Ha Noi, Hue and Da Nang stations. The means values are shown as the thick solid line in the plots.

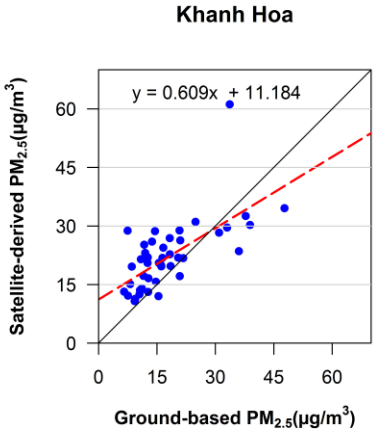
Validation

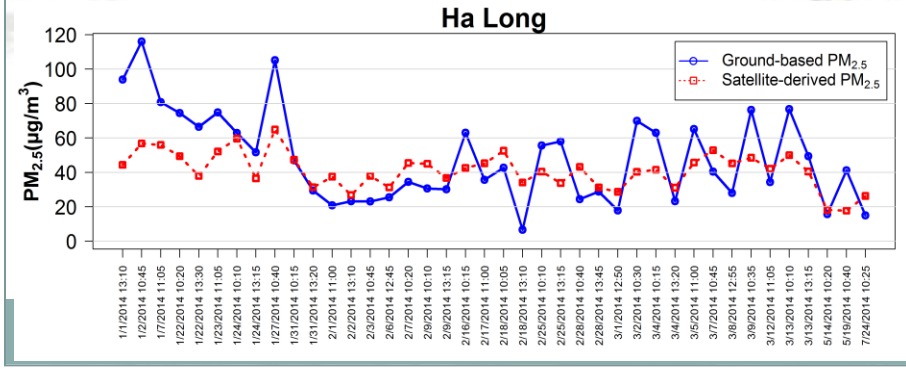
2. Independent validation

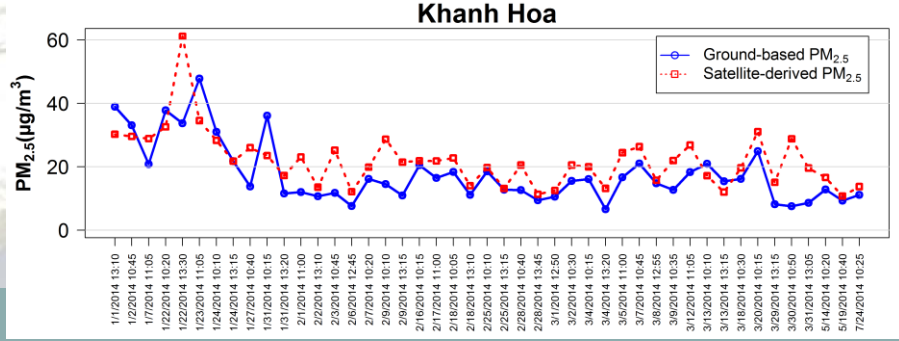
Station	#Samples	r^2	RMSE (μg/m³)	RE (%)	MFB (%)	MFE (%)
Ha Long	40	0.455	21.512	45.236	-2.975	38.695
Khanh Hoa	45	0.444	8.551	46.446	25.988	33.960

Independent validation of satellite-derived $PM_{2.5}$ and ground-based $PM_{2.5}$ at Ha Long and Khanh Hoa stations.

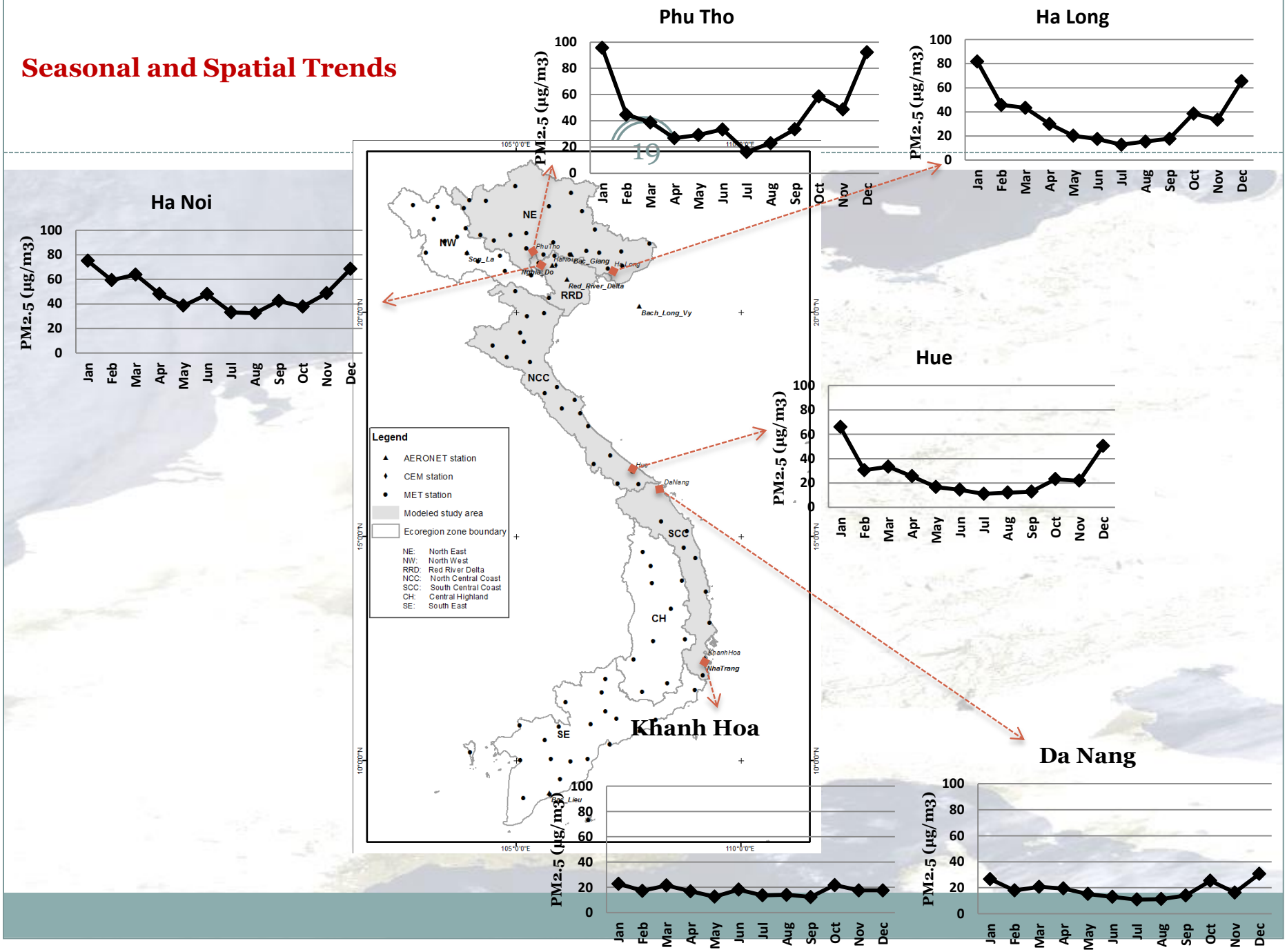


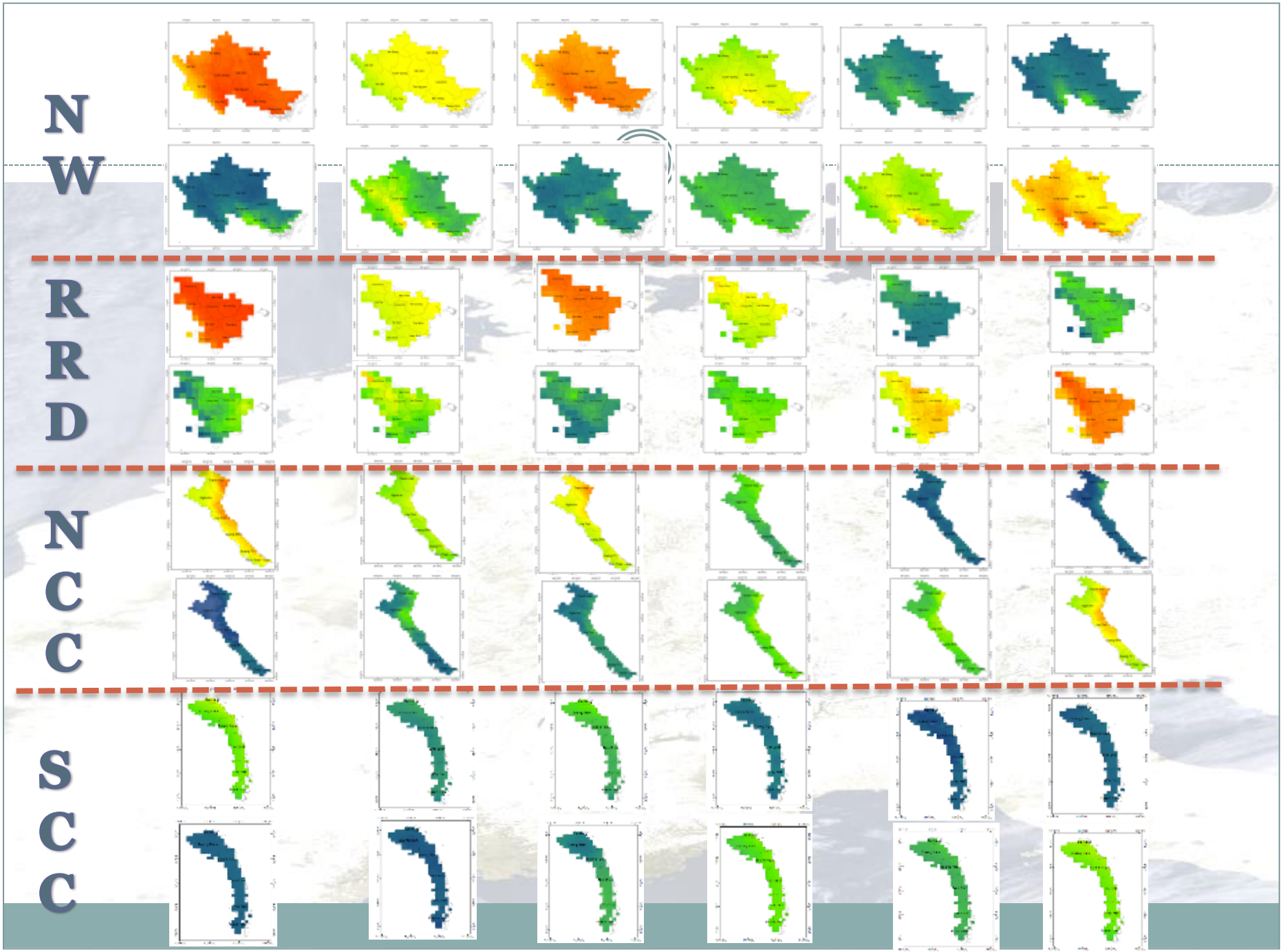






Seasonal and Spatial Trends




NW
RRD
NCC
SCC

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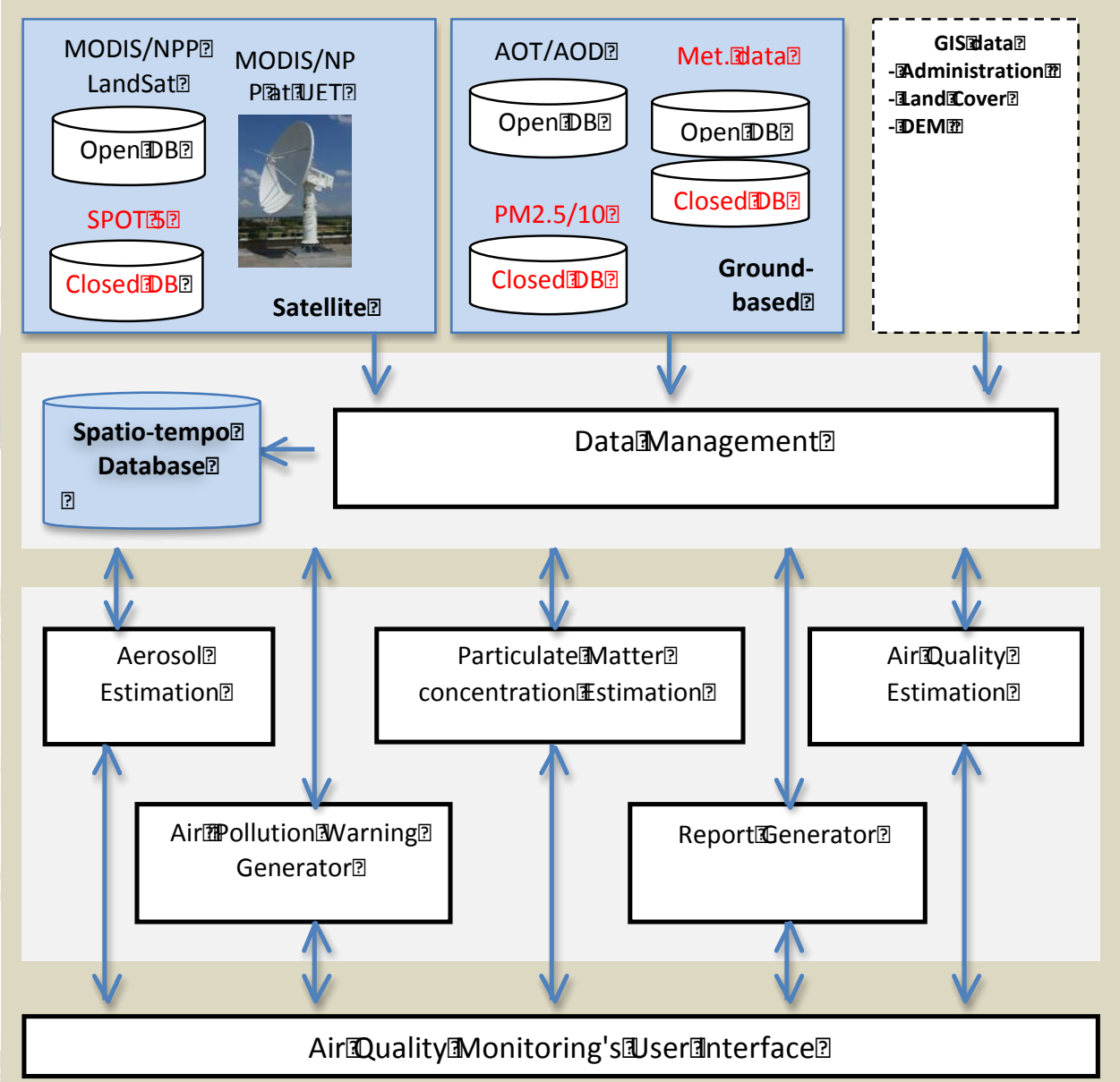
System Architecture



System Functions

APOM

System Management

- User management
- Permission management
- Category management

System Manager

Data Management

- Satellite Data (MODIS/VIIRS/LandSat)
- Ground Data (AERONET Aerosol, CEM PM)
- GIS Data

Data Manager

Processing

- Collect data (NASA, UET)
- Preprocessing & Save
- PM2.5 estimation over Vietnam
- AQI calculation (for each province)
- Warning by SMS/Email

Services

- Monitoring
- Search and Download
- Report
- Warning registration

Manager, Experts, Citizen

Monitoring

http://apom.fimo.edu.vn:8080/apom/web/

Search & Download

Registration of Warning Service

Monitoring

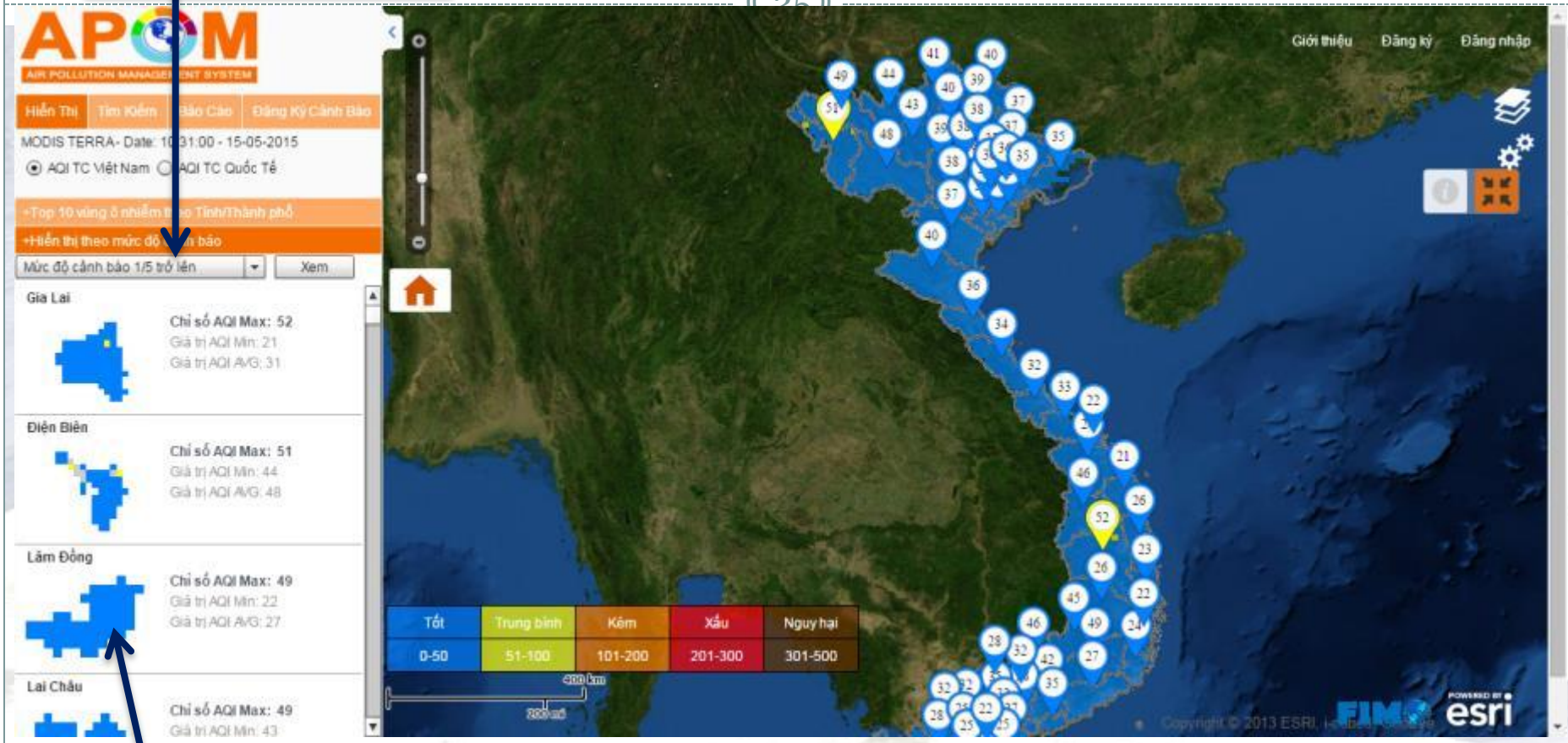
Report

Top tem polluted provinces

Air quality Scale

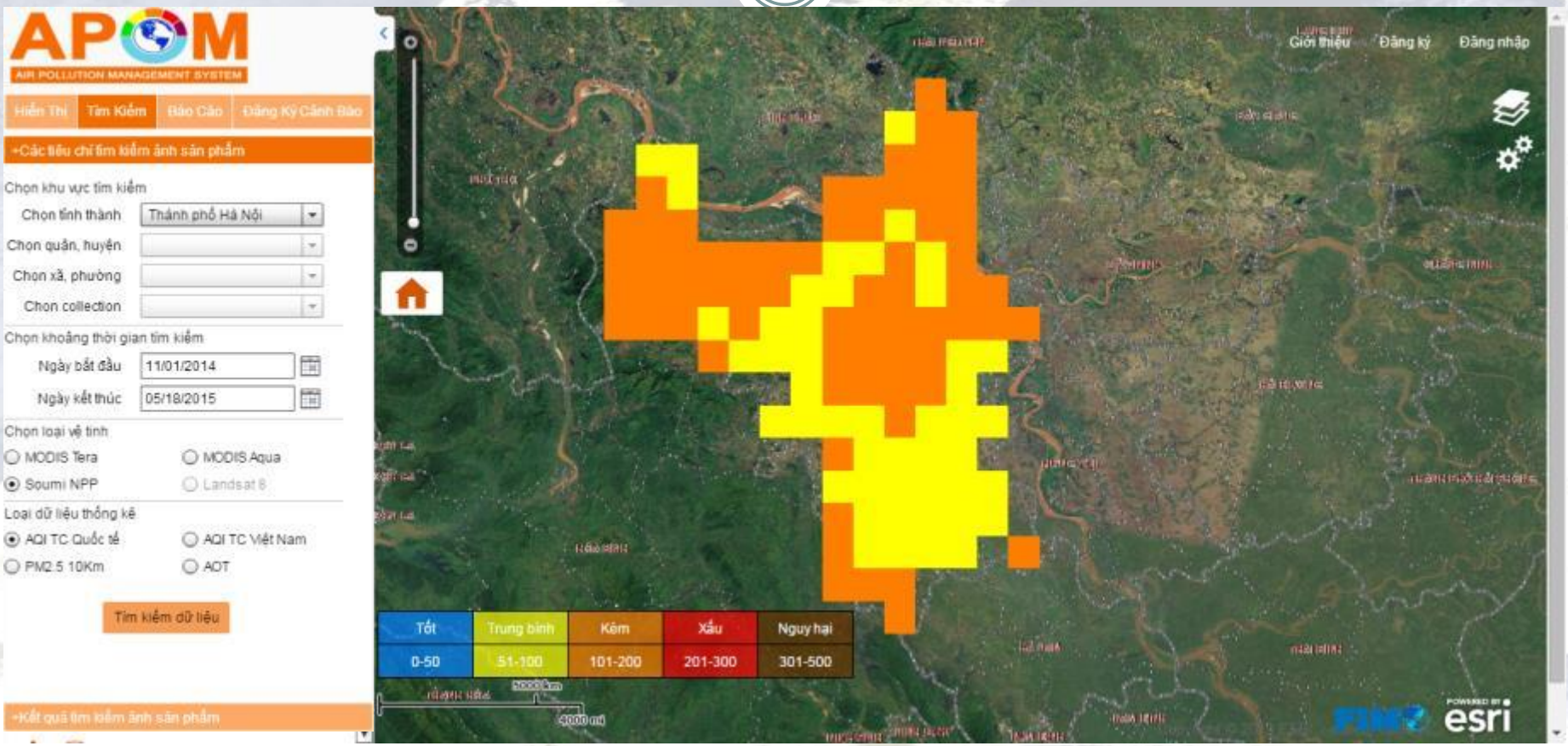
Monitoring

List provinces have the warning lever 1/5

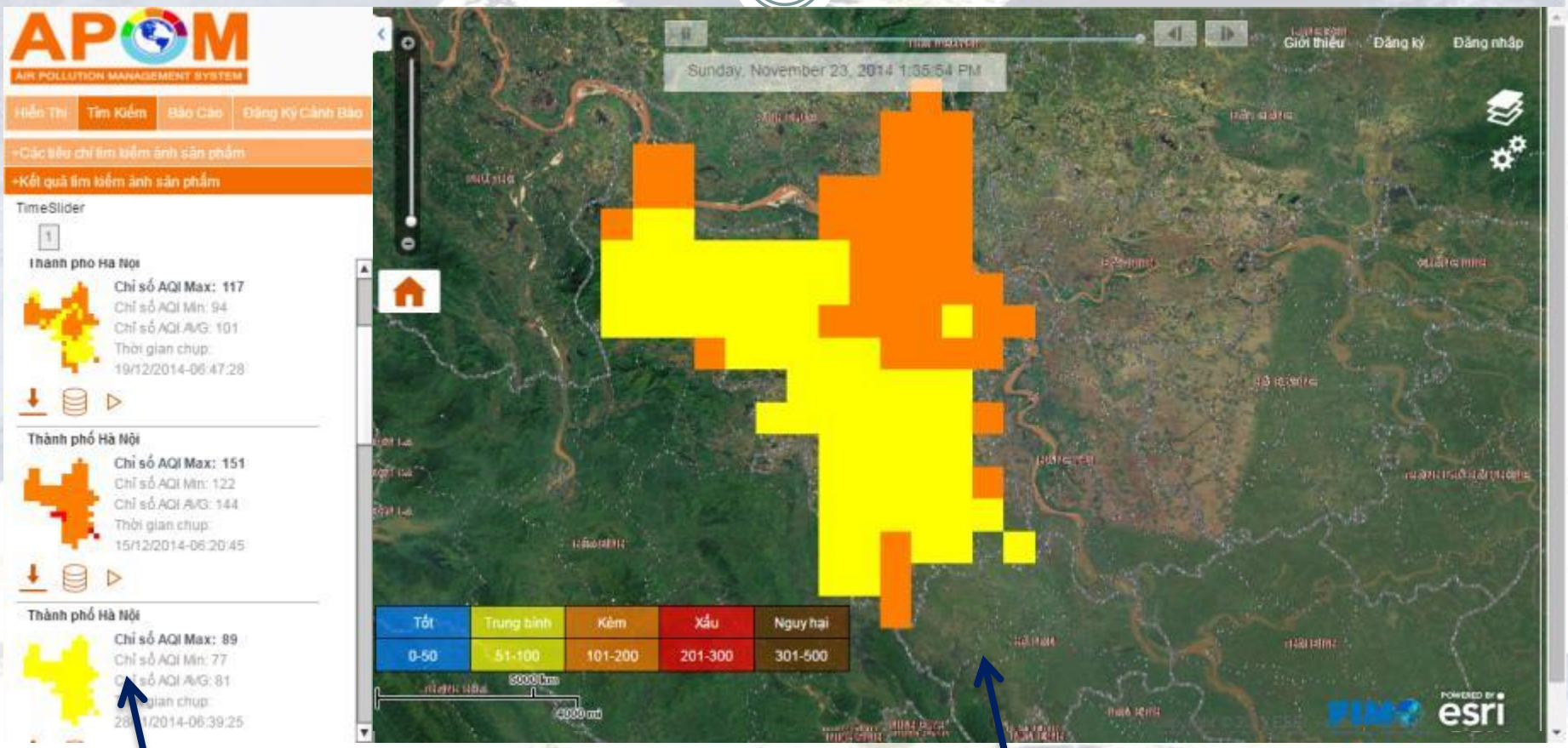


List of provinces

Search and Download Data



Search and Download Data

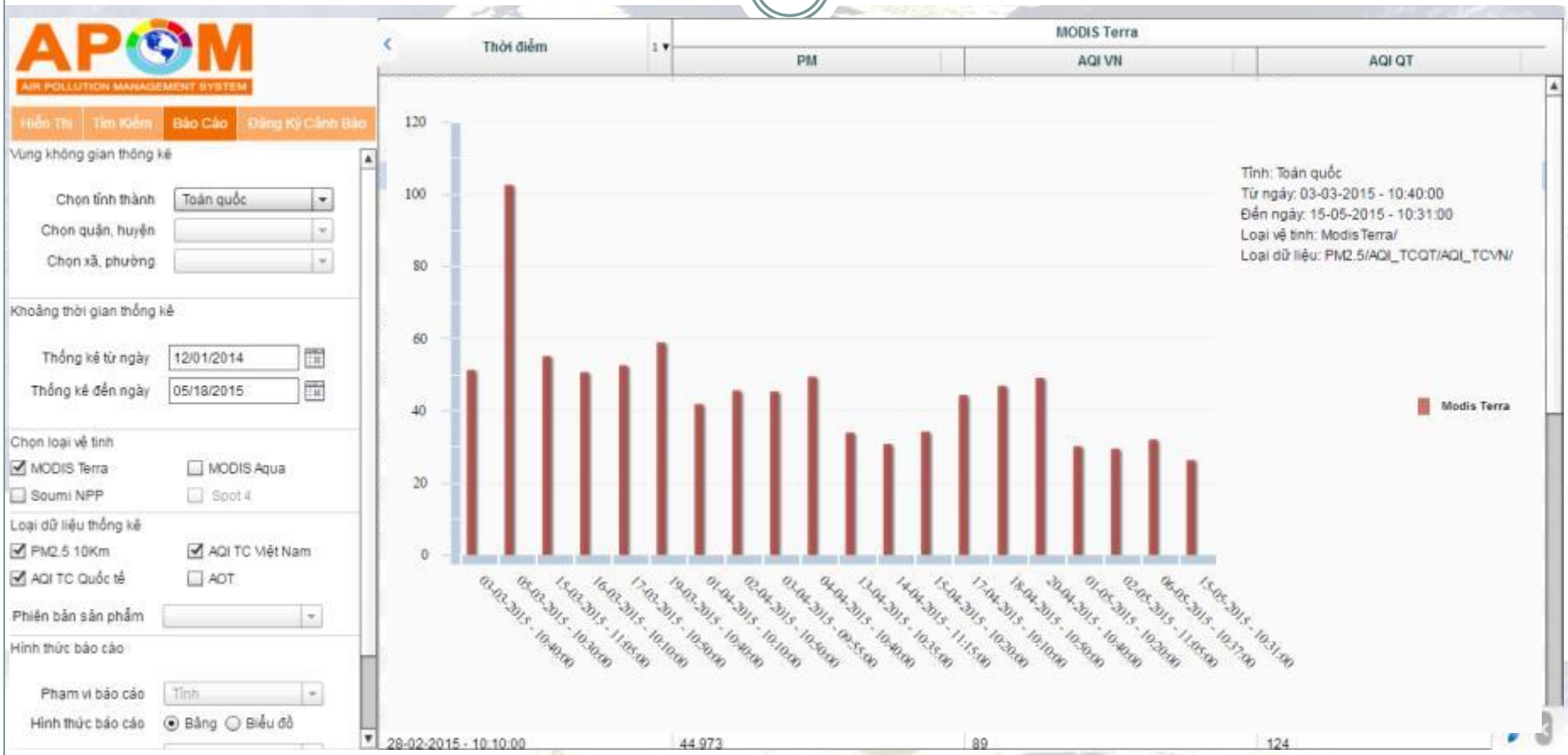


List of results

View & Time Animation

Reports

http://apom.fimo.edu.vn:8080/apom/web/



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Conclusion

- PM estimation at regional scale (Vietnam)
  - PM2.5 maps at 10 km using MODIS from Dec. 2010 – Sep. 2014
  - Modeling and validation were carried out for NE, RRD, NCC and SCC and obtained promising results
- Air Pollution Management system (APOM)
  - Online monitoring and warning system
  - Automatic data processing
  - Supporting system (data, user …) administration
  - Supporting user interface
- Open issues
  - Frequency of satellite-derived MODIS PM2.5 map is low (effect of cloud)
  - Validation in other regions (i.e.: NW, CH, SE)
  - Statistics approach (data-driven approach) vs. other approaches (model-driven approaches)
  - Model performance's improvement.

Acknowledgement

- This research was possible due to the funds received from project “Air pollution monitoring and warning system”, QGTD.13.27 from Vietnam National University, Hanoi.

Q & A

THANK YOU FOR YOUR ATTENTION