School of Environmental Science and Technology
Hanoi University of Science and Technology

Characteristics of haze in Southeast Asia and Hanoi

Presenter: Bich-Thuy Ly

Authors: Dieu-Anh Van, Tuan V. Vu, Trung-Dung Nghiem, Thu-Hien T. Nguyen, Le-Ha T. Vo, Nhung Hong Le, Phan H.T. Nguyen, Prapat Pongkiatkul, Quoc-Dat Nguyen Bich-Thuy Ly

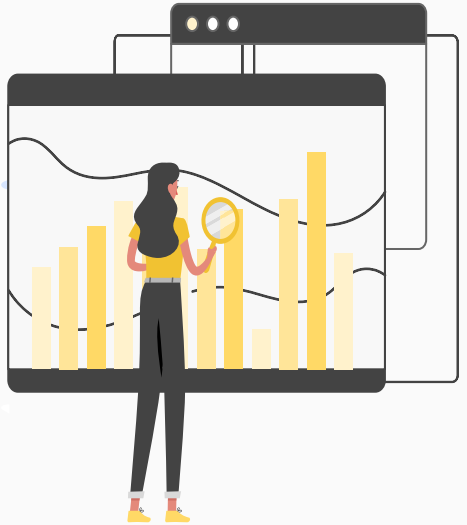
Hanoi, 3/2/2023

01
INTRODUCTION

02
HAZE in SOUTHEAST ASIA

03
HAZE IN HANOI

01
INTRODUCTION



- SEA is divided into two sub-regions, namely Mainland and Maritime
- In terms of regional meteorology, SEA is nominated by the Asia monsoon circulation with the Winter (*northern*) monsoon from November to March, the Summer (*southern*) monsoon from June to September, and the monsoon transition periods

Definition of haze

SCIENTIFIC TERMINOLOGY

- Haze is one of the atmospheric phenomena of air pollution that is associated with visibility impairment or visibility degradation.
- Note that not all reduction in visibility is visibility impairment. For instance, fog and clouds are not parts of scenic visibility impairment, while haze results from anthropogenic emissions or natural sources such as wildfires, volcanic eruptions, or wind blowing to dust.
- Particulate matter (PM) level is used as a criterion for haze episodes to reflect the term of air pollutants.

Definition of haze

World Meteorological Organization

Haze as the conditions with visibility within 1–5 km and threshold of relative humidity (RH) < 95% (WMO, 2014)

Haze as the conditions with visibility within 1–5 km and threshold of “a certain percentage” (e.g., 80%) (WMO, 2017)

Research criteria

criteria for determining haze episodes

Location	Average daily $PM_{2.5}$ concentration($\mu g.m^{-3}$)	Visibility (km)	Relative Humidity	Author
Malaysia	⩾ 35	< 10	Not Applicable	Sulonget al (2017)
Thailand	> 50	< 10	< 90%	Chomaneet al (2020)
Thailand	> 120*	Not Applicable	Not Applicable	KimOanh, Leelasakultum(2011)
SEA	> 50	< 5	< 90%	DieuAnhet al (2022)
Hanoi	> 100	Not Applicable	Not Applicable	BichThuyet al (2018)
Hanoi	Not Applicable	< 5	<95%	Bao Anh et al (2019)

Definition of haze

Legal regulation

The Association of Southeast Asian nations

Haze pollution is defined as smoke resulting from land and/or forest fire that endangers human health, harms living resources, ecosystems, and material property, and impairs or interferes with amenities and other legitimate uses of the environment.

Singapore government

The transboundaryhaze in the National Transboundary Haze Pollution Act is defined as air pollution episodes involving smoke or forest fires outside Singapore

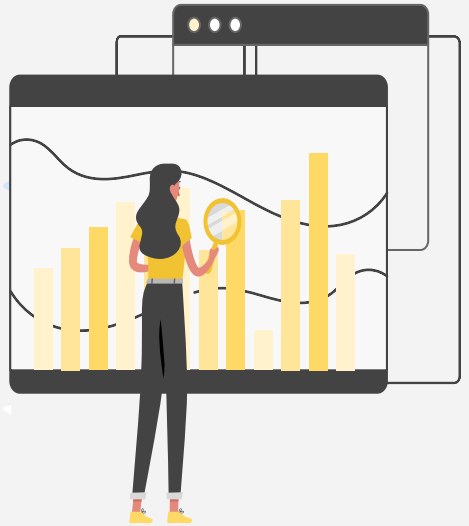
Definition of haze

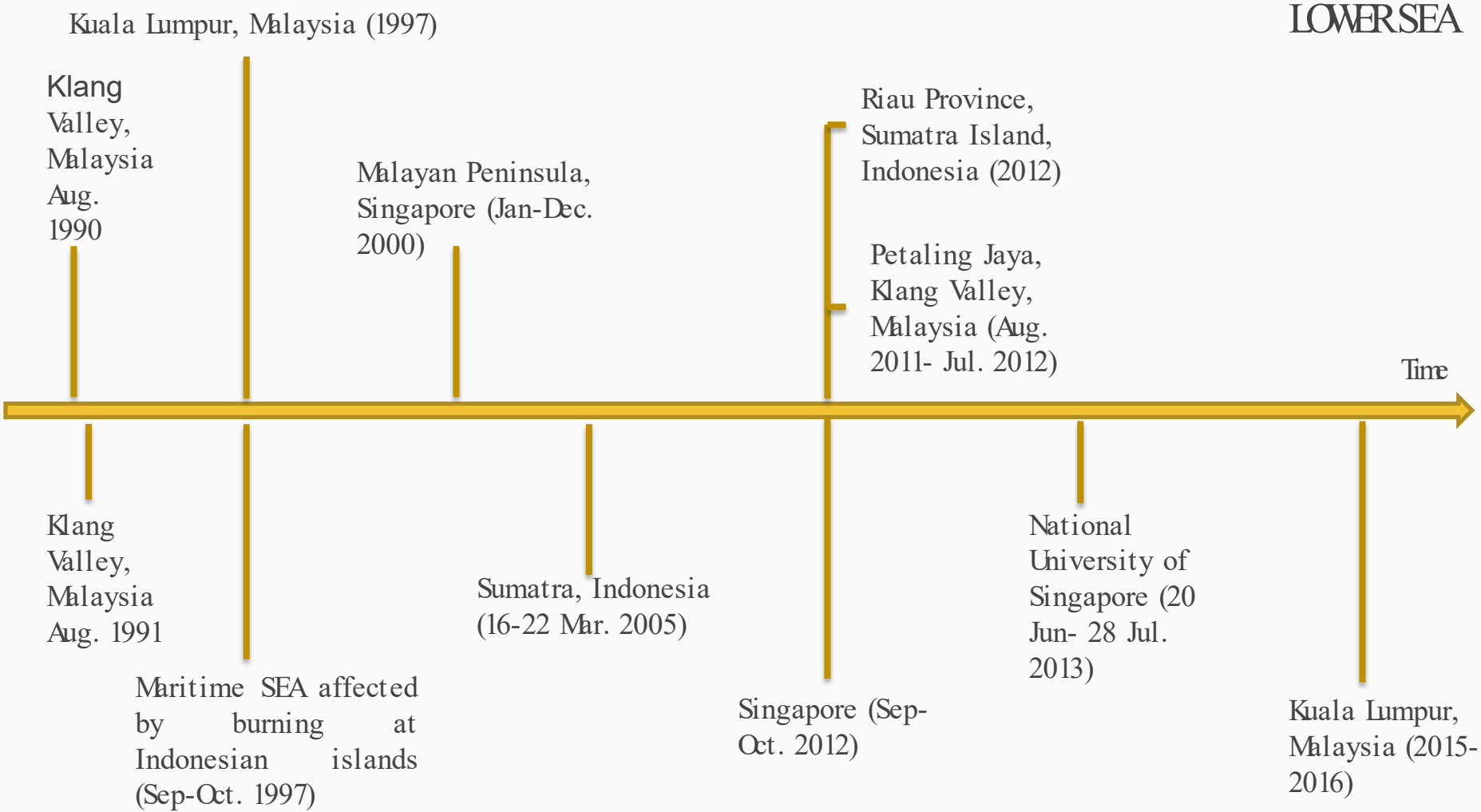
In this research, we proposed criteria for a haze day are daily $PM_{2.5}$ > 50 µg/m^3 and visibility < 5 km and RH < 90%

Based on WHO Interim Target-2 and Vietnamese ambient air quality standard

Based on the criteria of WMO visibility 1-5km ((WMO, 2014, 2017); RH< 95% (WMO, 2014) or “certain percentage” (*e.g.*, 80%) (WMO, 2017)

02.
HAZE IN SOUTHEAST ASIA

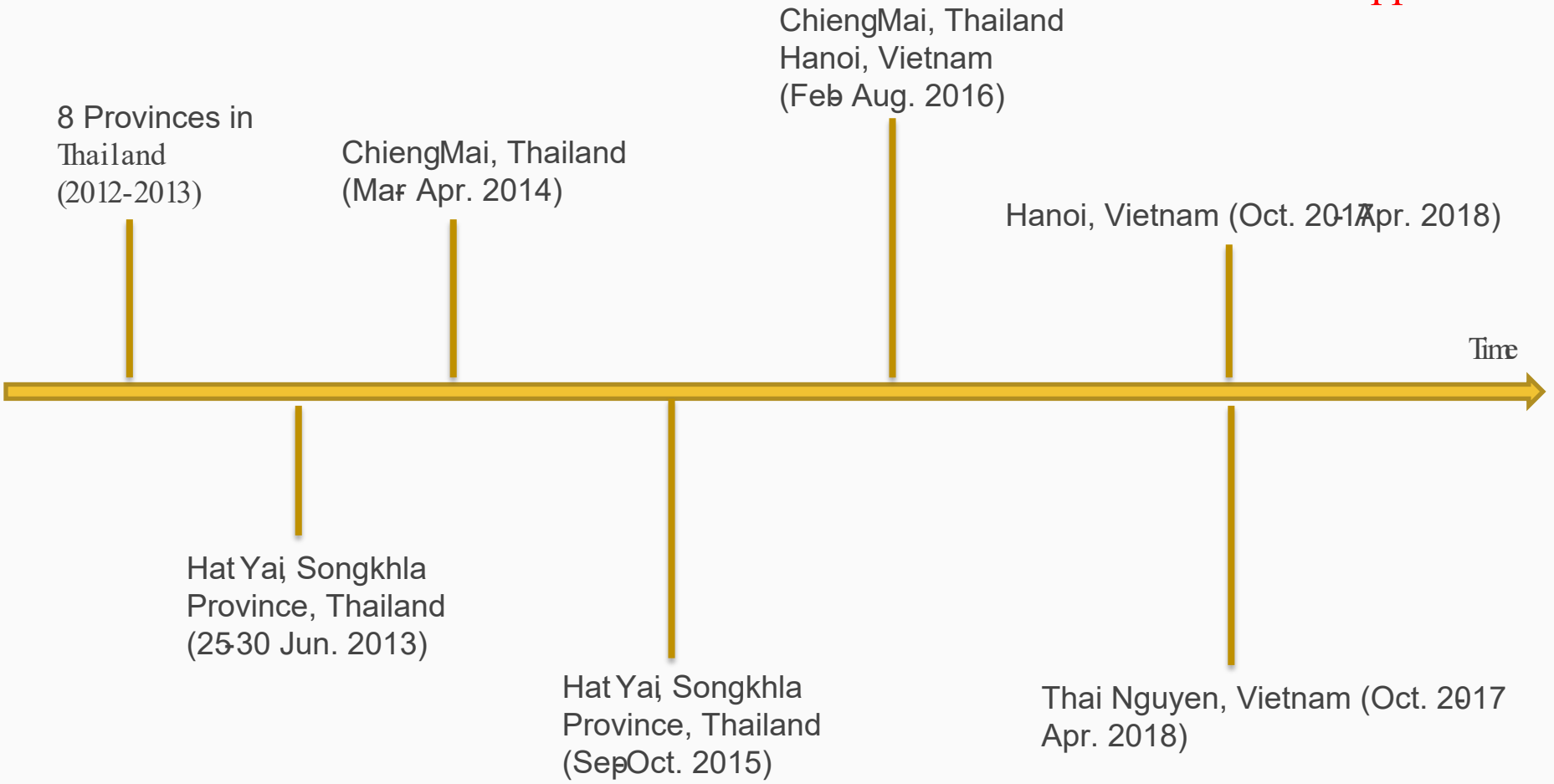



Kuala Lumpur, Malaysia (1997)
Klang Valley, Malaysia Aug. 1990
Malayan Peninsula, Singapore (Jan-Dec. 2000)
Riau Province, Sumatra Island, Indonesia (2012)
Petaling Jaya, Klang Valley, Malaysia (Aug. 2011- Jul. 2012)
Time
Klang Valley, Malaysia Aug. 1991
Maritime SEA affected by burning at Indonesian islands (Sep-Oct. 1997)
Sumatra, Indonesia (16-22 Mar. 2005)
Singapore (Sep-Oct. 2012)
National University of Singapore (20 Jun- 28 Jul. 2013)
Kuala Lumpur, Malaysia (2015-2016)

Water-soluble ions of pm haze Lower sea Contribution of SIA (%); $PM_{2.5}$ ($\mu g/m^3$)

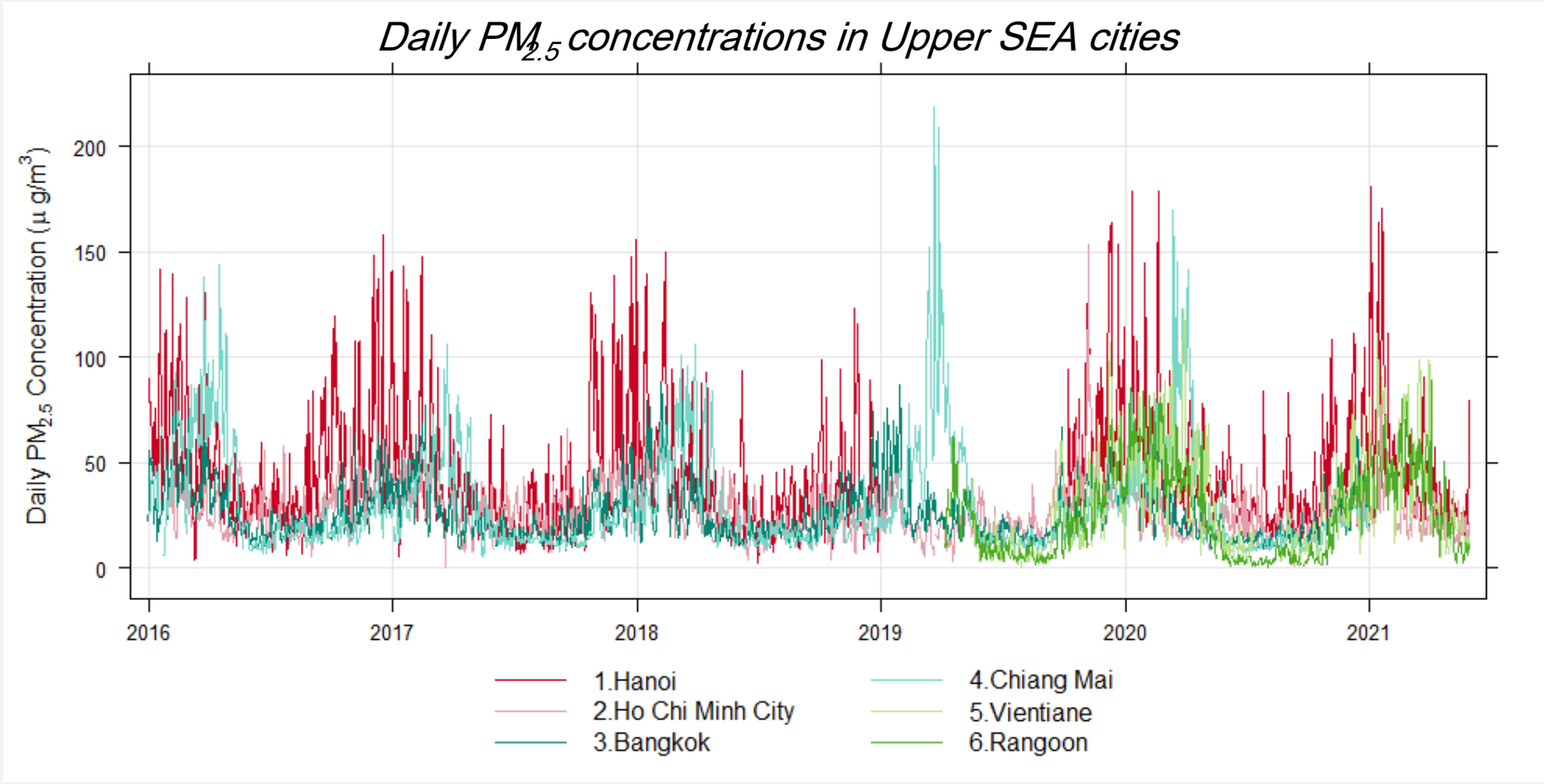
Countries	Sampling Period	Site	$PM_{2.5}$	SO_4^{2-}	NO_3^-	NH_4^+	$SO_4^{2-} + NO_3^- + NH_4^+$	K^+
Indonesia	16-22 Mar.2005	Sungai Sembilan	1600	1.9	1.9	0.8	4.6	0.8
		Belakang Rumah	640	3.3	4.5	0.7	8.5	0.3
		Pekanbaru	140	10.7	1.9	0.8	13.4	1.4
Malaysia Peninsula	Aug.2011-Jul.2012	Klang Valley	61	3.9	0.4	3.6	7.9	0.0
Malaysia Peninsula	21-27 Jun.2013	UKM Bangi	79.4	3.9	1.2	-	-	0.8
Malaysia Peninsula	Jun.2015-Jan.2016	Kuala Lumpur	72.3	28.2	5.3	9.9	43.4	0.8
Singapore	May.2012-Jun.2013 & Jun.2015-Dec.2015	National University of Singapore	60.6	13.2	-	-	-	1.1
		National University of Singapore	199.9	3.8	-	-	-	0.5

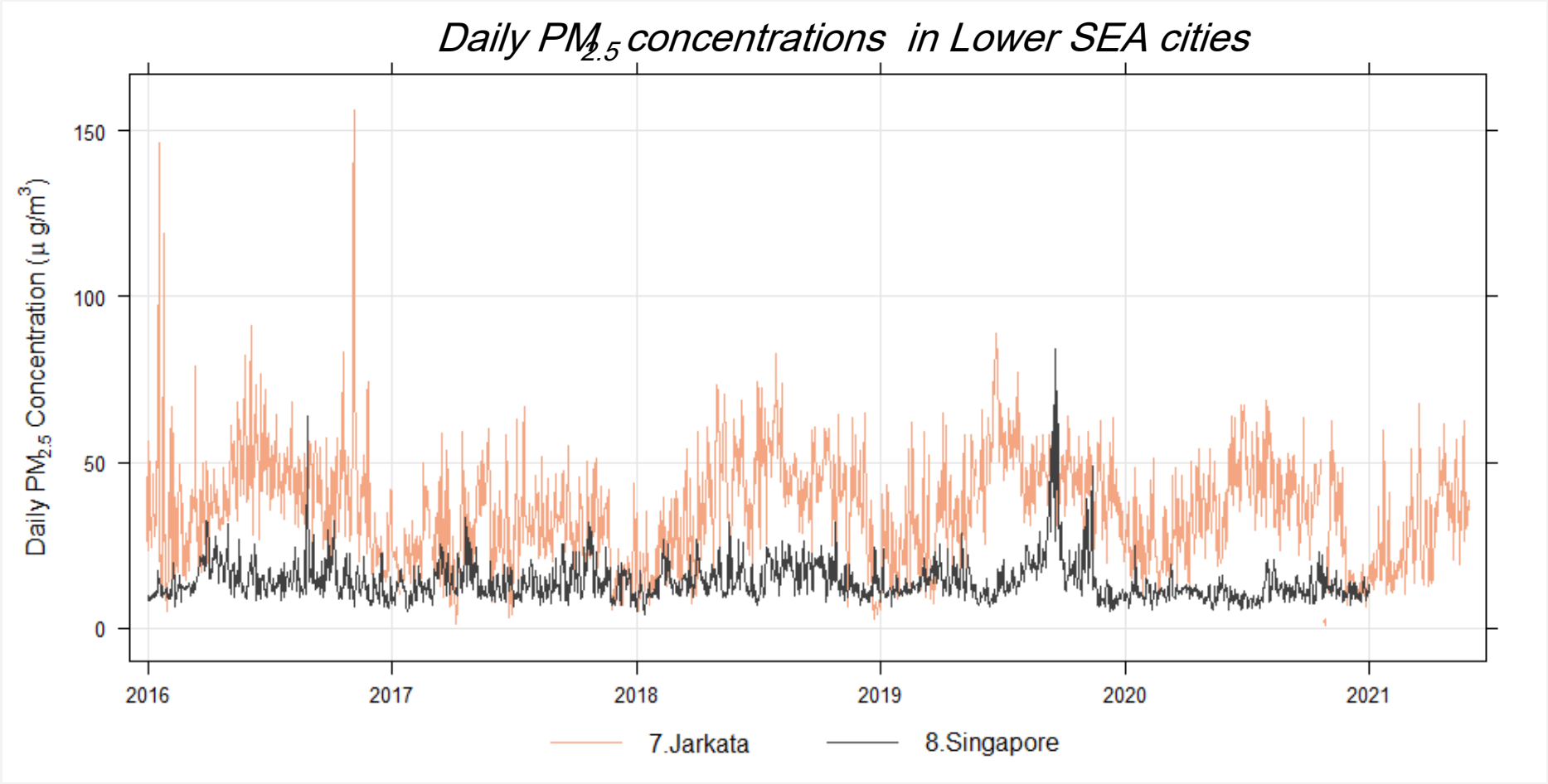
upper SEA


8 Provinces in Thailand (2012-2013)
ChiengMai, Thailand (Mar.- Apr. 2014)
ChiengMai, Thailand
Hanoi, Vietnam
(Feb.- Aug. 2016)
Hanoi, Vietnam (Oct. 2017- Apr. 2018)
Time
Hat Yai, Songkhla Province, Thailand (25-30 Jun. 2013)
Hat Yai, Songkhla Province, Thailand (Sep.-Oct. 2015)
Thai Nguyen, Vietnam (Oct. 2017- Apr. 2018)

Water-soluble ions of pm haze upper sea Contribution of SIA (%); $PM_{2.5}$ ($\mu g/m^3$)

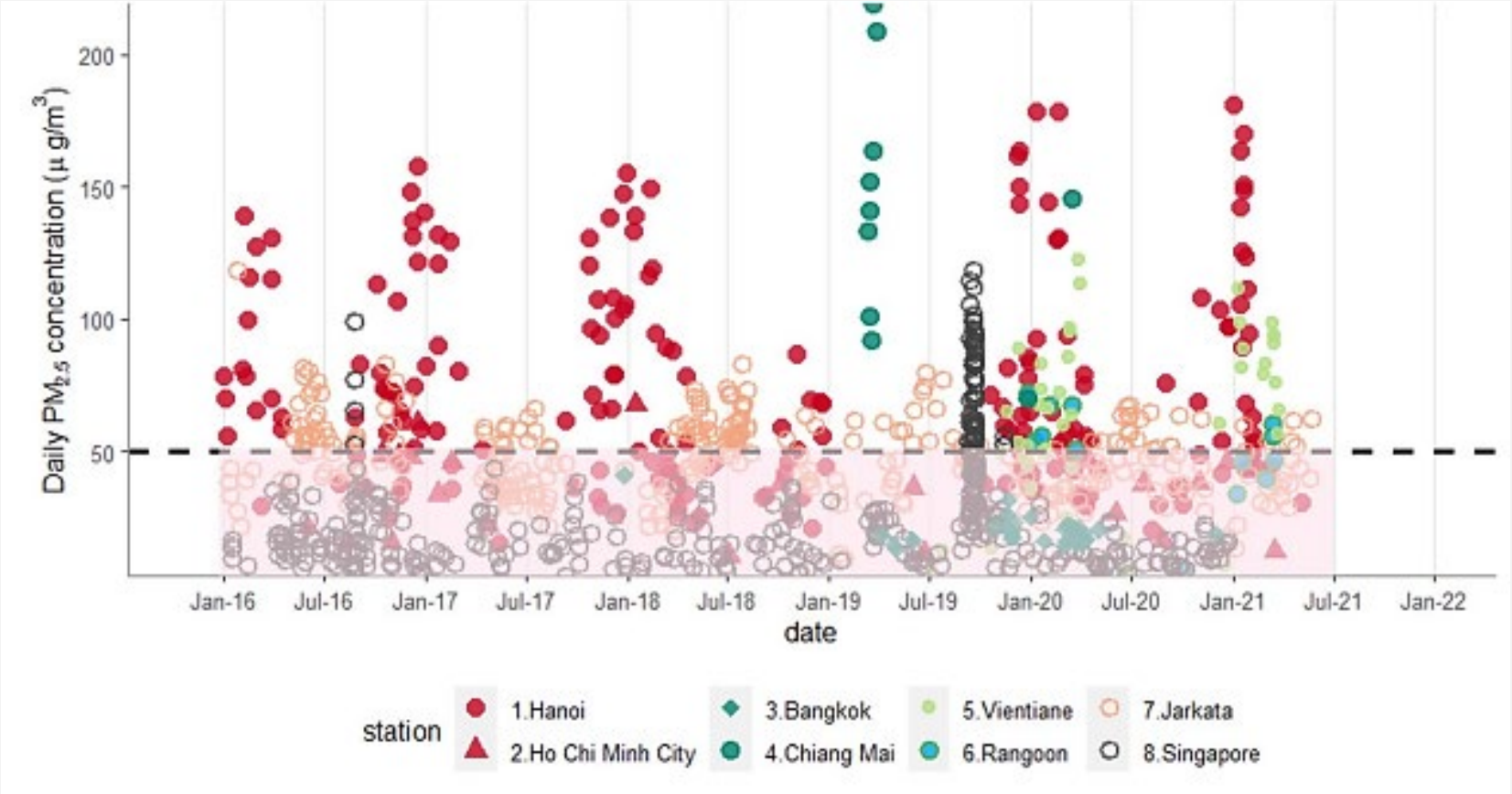
Countries	Sampling Period	Site	$PM_{2.5}$	SO_4^{2-}	NO_3^-	NH_4^+	$SO_4^{2-} + NO_3^- + NH_4^+$	K^+
Thailand	Mar to mid Apr.2014	CMU-urban site	**91.9**	**8.5**	**2.9**	**3.3**	**14.7**	**2.2**
Thailand	Mar to mid Apr.2014	DAK Doi Ang Khang - near source site	**82.1**	**7.6**	**5.0**	**3.6**	**16.1**	**2.2**
Thailand	23 Feb – 28 Apr.2016	Chiang Mai (CMU)	**64.3**	**14.1**	**4.3**	**5.3**	**23.8**	**1.9**


Daily PM2.5 concentrations in Upper SEA cities
Daily PM2.5 Concentration (μ g/m3)
0
50
100
150
200
2016
2017
2018
2019
2020
2021
1.Hanoi
2.Ho Chi Minh City
3.Bangkok
4.Chiang Mai
5.Vientiane
6.Rangoon

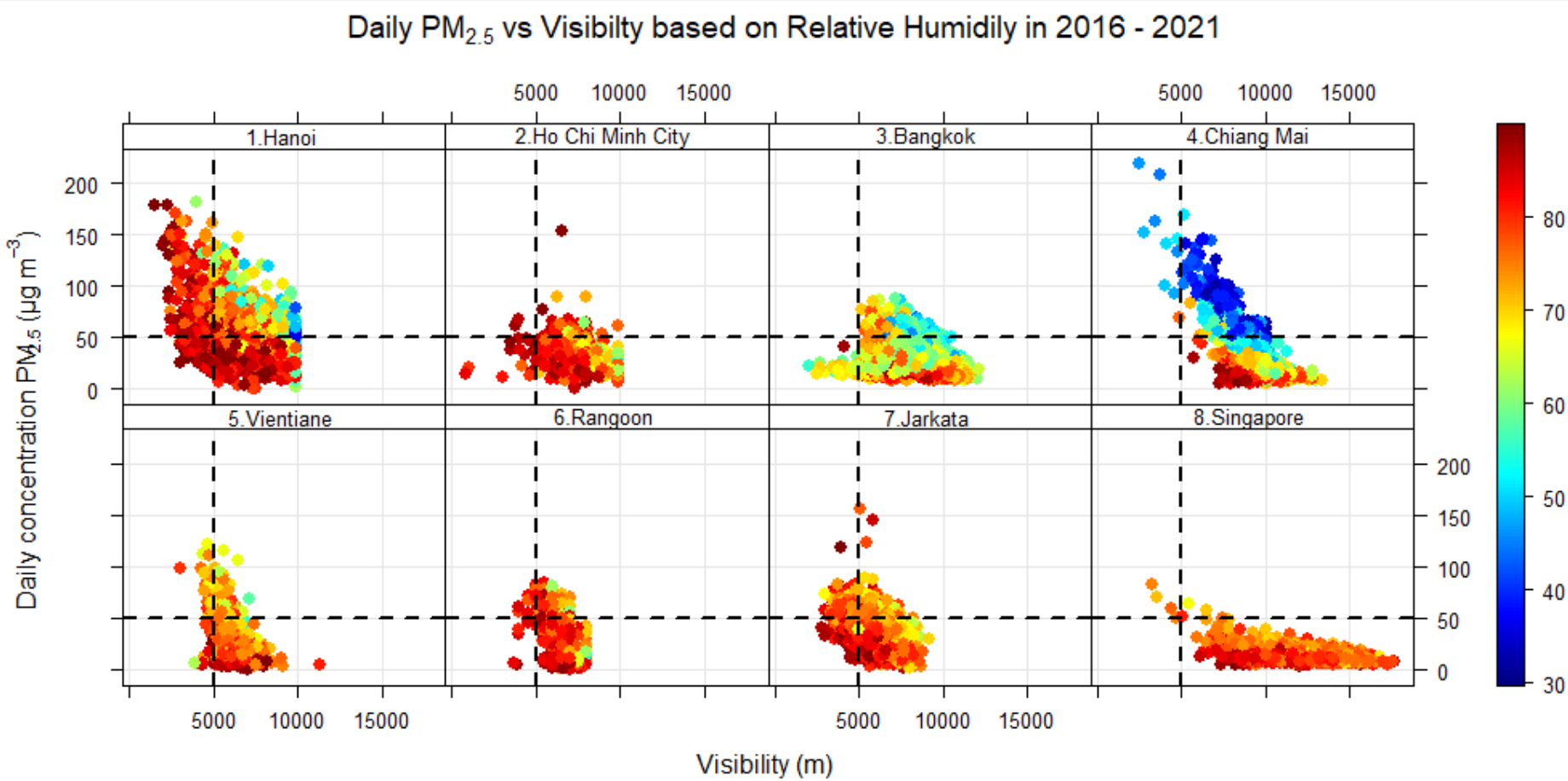

Daily PM2.5 concentrations in Lower SEA cities
Daily PM2.5 Concentration (μ g/m3)
150
100
50
0
2016
2017
2018
2019
2020
2021
7.Jarkata
8.Singapore

The criteria for a haze day proposed are $PM_{2.5}$ > 50 µg/ m^3, Visibility <5 km, and RH <90%

Comparing haze conditions in different cities using a haze definition



Comparing haze conditions in different cities using a haze definition



Cause of haze

Contributing sources

The $PM_{2.5}$ sources in SEA countries include traffic, biomass burning, industry, dust, sea salt, and unspecified-human origin.
Almost all studies have shown that biomass burning is a significant emission source contributing to the haze. Additionally, the contribution of biomass burning in the mainland and the maritime SEA are different.

Effect of long-range transport

Long-range transport inside the SEA that brings biomass burning is an important contribution to haze in Lower SEA in summer and even in some parts of Upper SEA.

Cause of haze

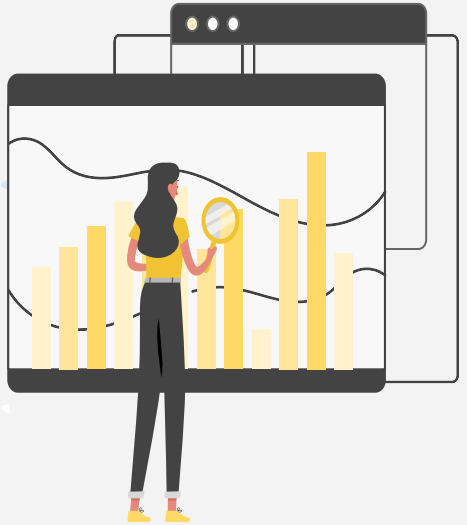
Secondary inorganic aerosol formation

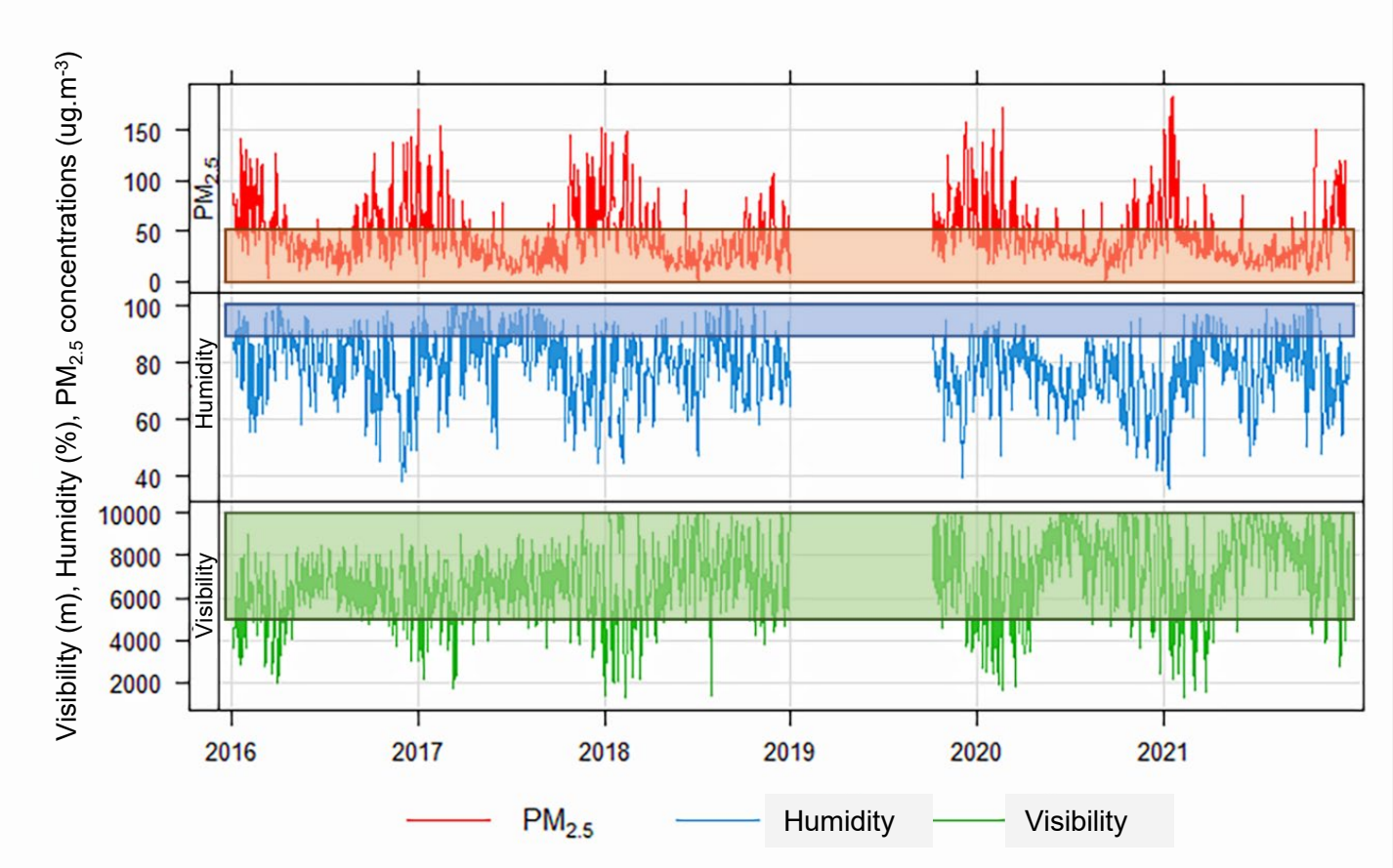
The percentage of inorganic ions in PM that is presented for secondary inorganic formation is summarized in slides 12-14. In general, levels of secondary inorganic aerosol (SIA) in haze periods are higher than those in non-haze periods.

Secondary formation pathways are important factors that contribute to haze events that are related to long-range transportation,… those passing the sea.

Secondary organic aerosol formation

03.
HAZEIN
HAnoi

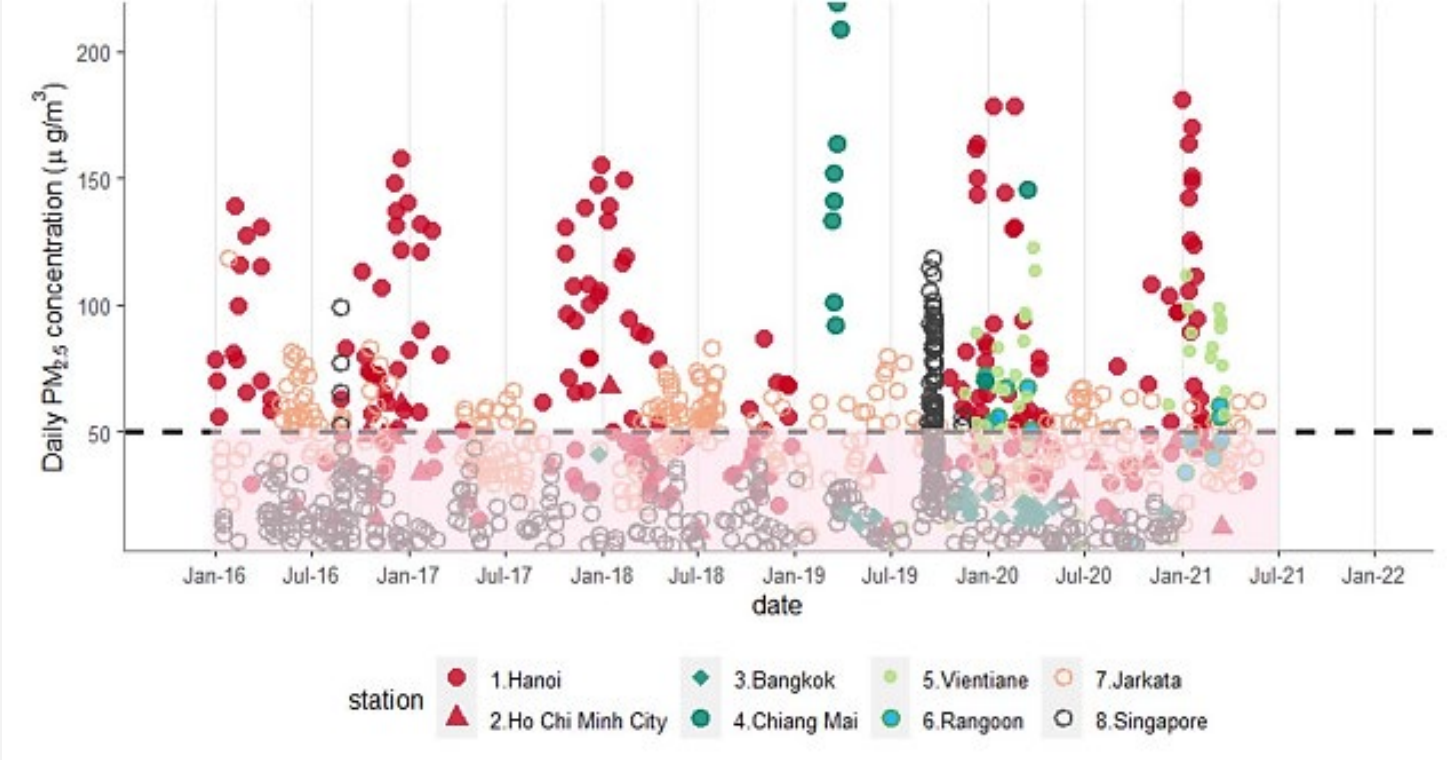




Variations of $PM_{2.5}$, visibility, and relative humidity in Hanoi in the period 2016-2021. The shading area denotes for not met haze criteria

The criteria for a haze day are $PM_{2.5}$ > 50 μg/m^3, Visibility <5 km, and RH <90%

Daily PM2.5 concentrations in haze events



The orange sharing area shows $PM_{2.5}$ levels below 50 μg/m^3
(The points in this area are not counted as haze events)

dr y wint er

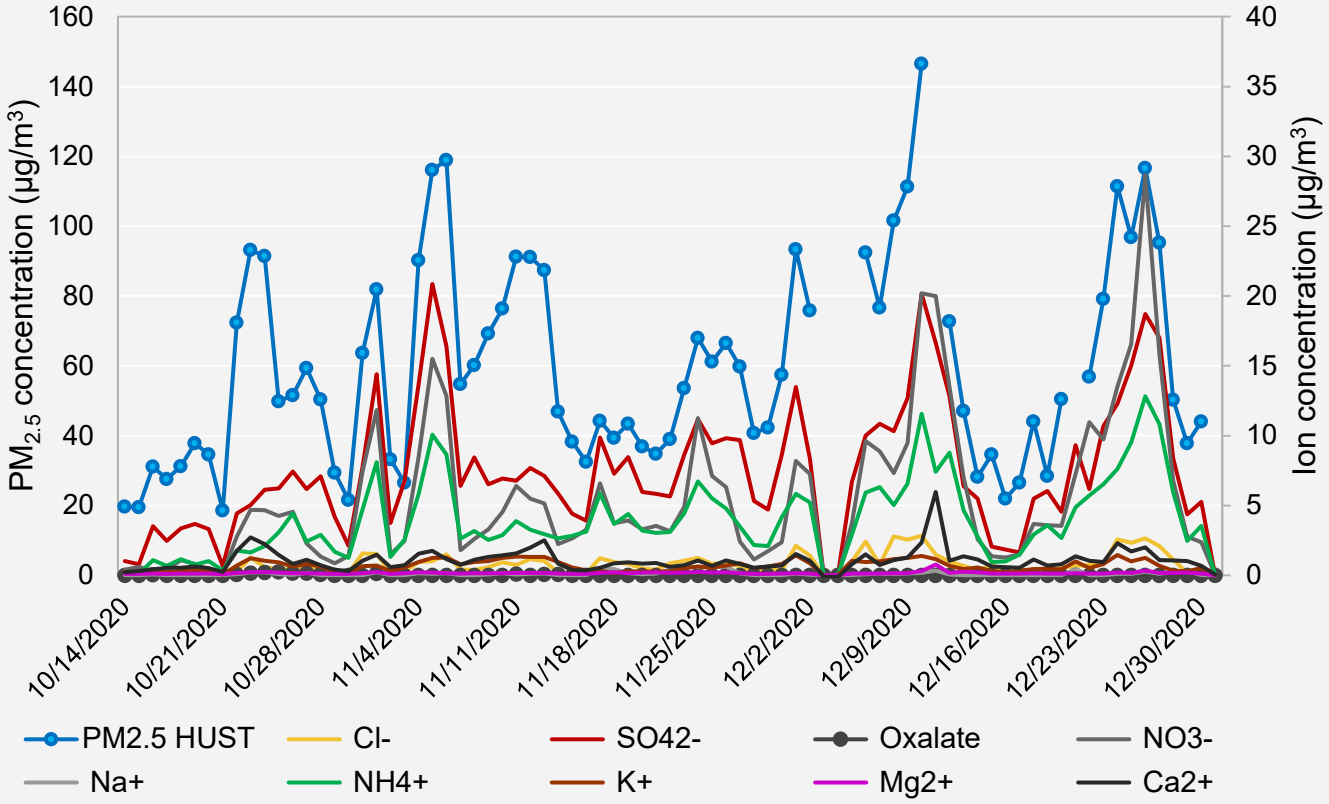
Statistics about haze in Hanoi

Number	Time	Periods	Average duration of periods (day)	Average $PM_{2.5}$	$PM_{2.5}$ means of lowest haze period	$PM_{2.5}$ means of highest haze period
1	1/10/2016 31/12/2016	6	1 – 2 (1.5)	113,8	67,6	143,7
2	1/10/2017 31/12/2017	7	1 – 3 (1,4)	115,5	81,1	152,5
3	1/10/2018 31/12/2018	5	1 (1,0)	61,1	52,1	79,5
4	1/10/2019 31/12/2019	4	1 – 3 (1,8)	107,8	55,9	158,7
5	1/10/2020 31/12/2020	4	1 – 2 (1,3)	83,9	52,5	113,8
6	1/10/2021 31/12/2021	5	1 – 2 (1,4)	100,9	71,3	119,7

Statistics about haze in Hanoi

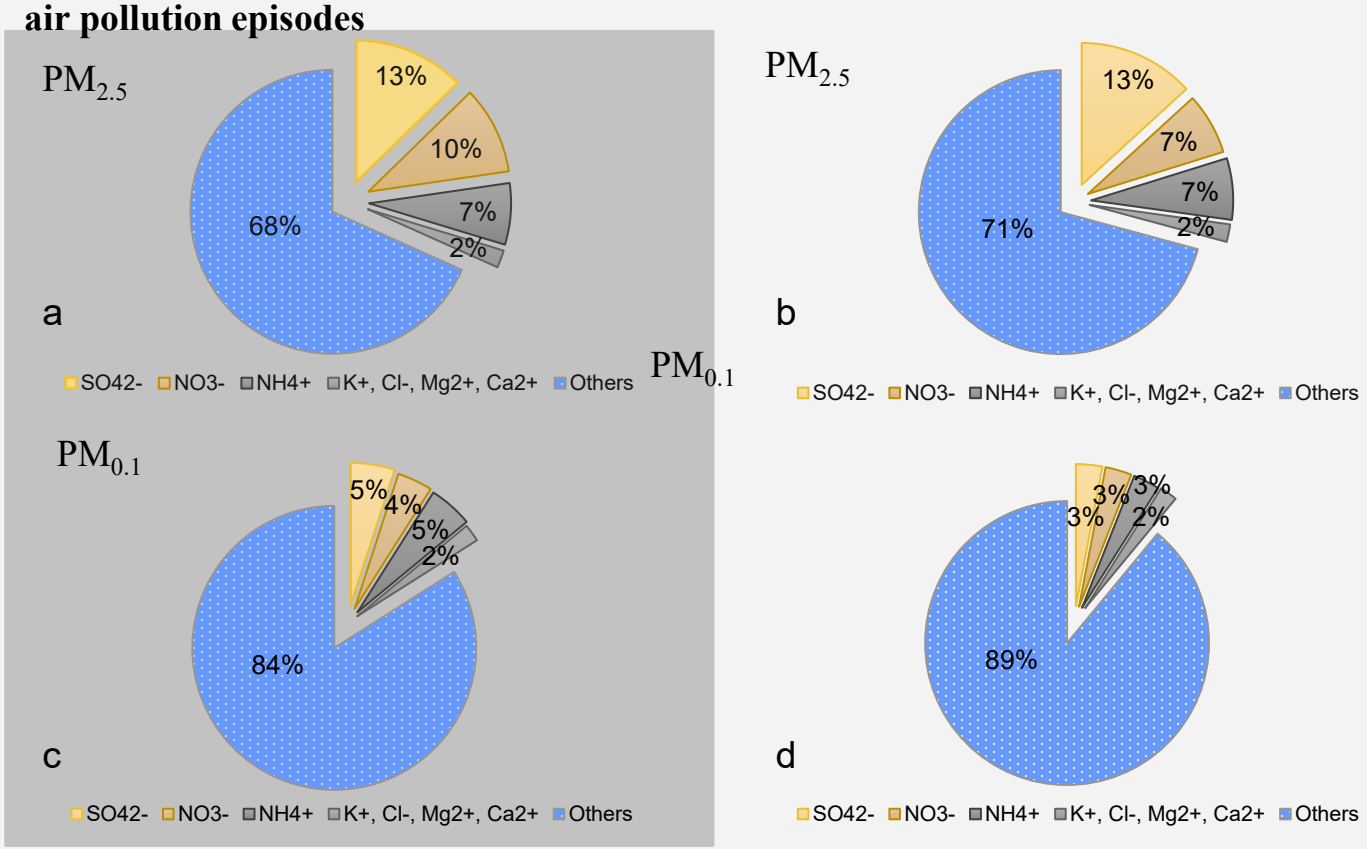
Number	Time	Periods	Average duration of periods (day)	Average $PM_{2.5}$	$PM_{2.5}$ means of lowest haze period	$PM_{2.5}$ means of highest haze period
1	1/1/2016 31/3/2016	6	1 – 3 (1,5)	99,4	68,4	126,7
2	1/1/2017 31/3/2017	5	1 – 3 (1,8)	89,4	55,9	154,9
3	1/1/2018 31/3/2018	12	1 – 3 (1,6)	82,4	53,5	148,8
4	1/1/2019 31/3/2019	Data lost				
5	1/1/2020 31/3/2020	11	1 – 3 (1,6)	102,7	51,8	172,8
6	1/1/2021 31/3/2021	6	1 – 6 (2,3)	110,2	50,2	182,9

$PM_{2.5}$ concentration and water soluble ions and (Dry winter, 2020)

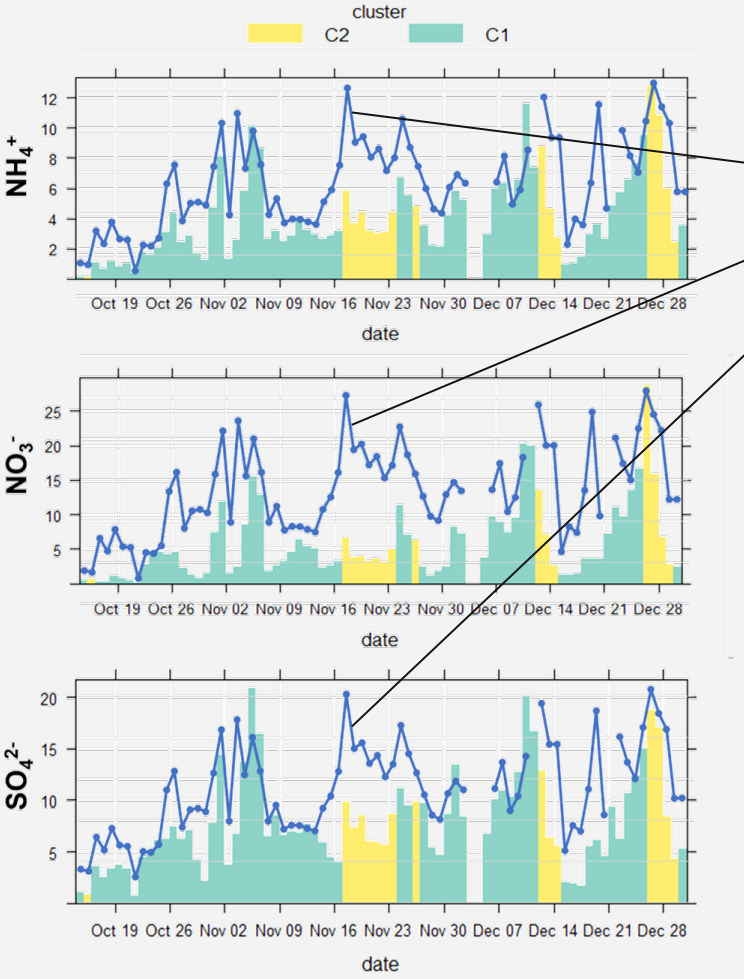


Secondary inorganic aerosol (In Dry winter, 2020)

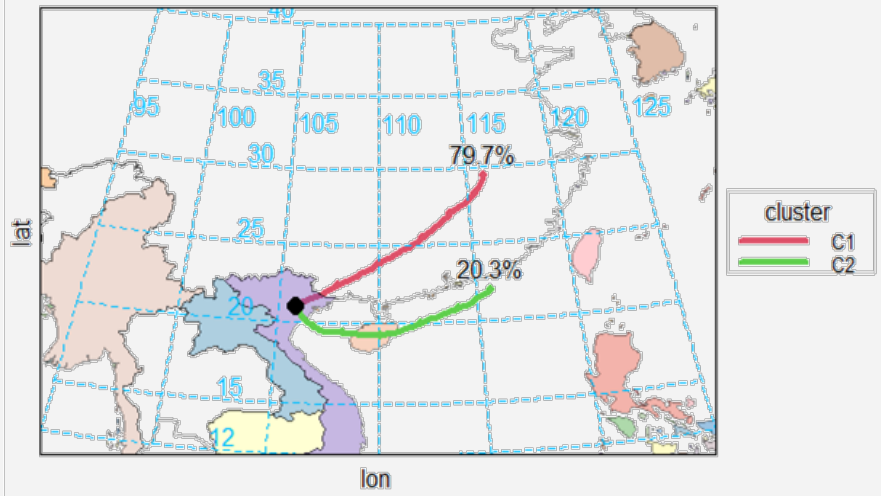
The criteria for an **air pollution episodes** are $PM_{2.5}$ > 50 μg/ m^3



Effects of long-range transport on $PM_{2.5}$ levels during dry winter 2020



Contribution of SIA to $PM_{2.5}$



SIA contribution to $PM_{2.5}$ increased significantly during episodes affected by cluster 2 although their concentration was low.

SIA concentration variation corresponding to the air trajectory clusters

The influence of meteorological parameters on the variation of $PM_{2.5}$ concentrations

Method: Multivariable linear regression.

Result: Meteorological factors could explain approximately 50% of $PM_{2.5}$ variations in both haze and non-haze events.

THANK YOU FOR YOUR Listening!

y