Annual Air Quality Review

January 2017

WELCOME

Executive Summary

1. Regional improvement over 10 years provides strong ground for a more stringent Air Quality Objectives

2. A closer analysis of the air pollution data leads to the below findings:
   - Diurnal pattern suggests the correlation between traffic activities and air pollution
   - Air pollution increases with heavy traffic flow and consequently higher exposure time of commuters
   - The West part of Hong Kong is more severe than the East

3. Social cost of heavy traffic
   - Nitrogen Dioxide has never reached safe level over the past 20 years
   - Substantial costs on health, traffic time, living quality

4. There is a limitation of roadside emission measures (“end-of-pipe” solutions) observed, as a review of “A Clean Air Plan for Hong Kong”

5. Further insights

Table of Contents

Source of Information

- Hedley Environmental Index of HKU
- EPD Air Monitoring Station Data
- Report on Study of Road Traffic Congestion in Hong Kong, 2014 (by Transport Advisory Committee)
- 2011 Hong Kong Population Census (Census and Statistics Department)
- 2015 traffic census
- Google Traffic
- HRAPIE Project (by European Union)
- Guangdong-Hong Kong-Macao Pearl River Delta Regional Air Quality Monitoring Network

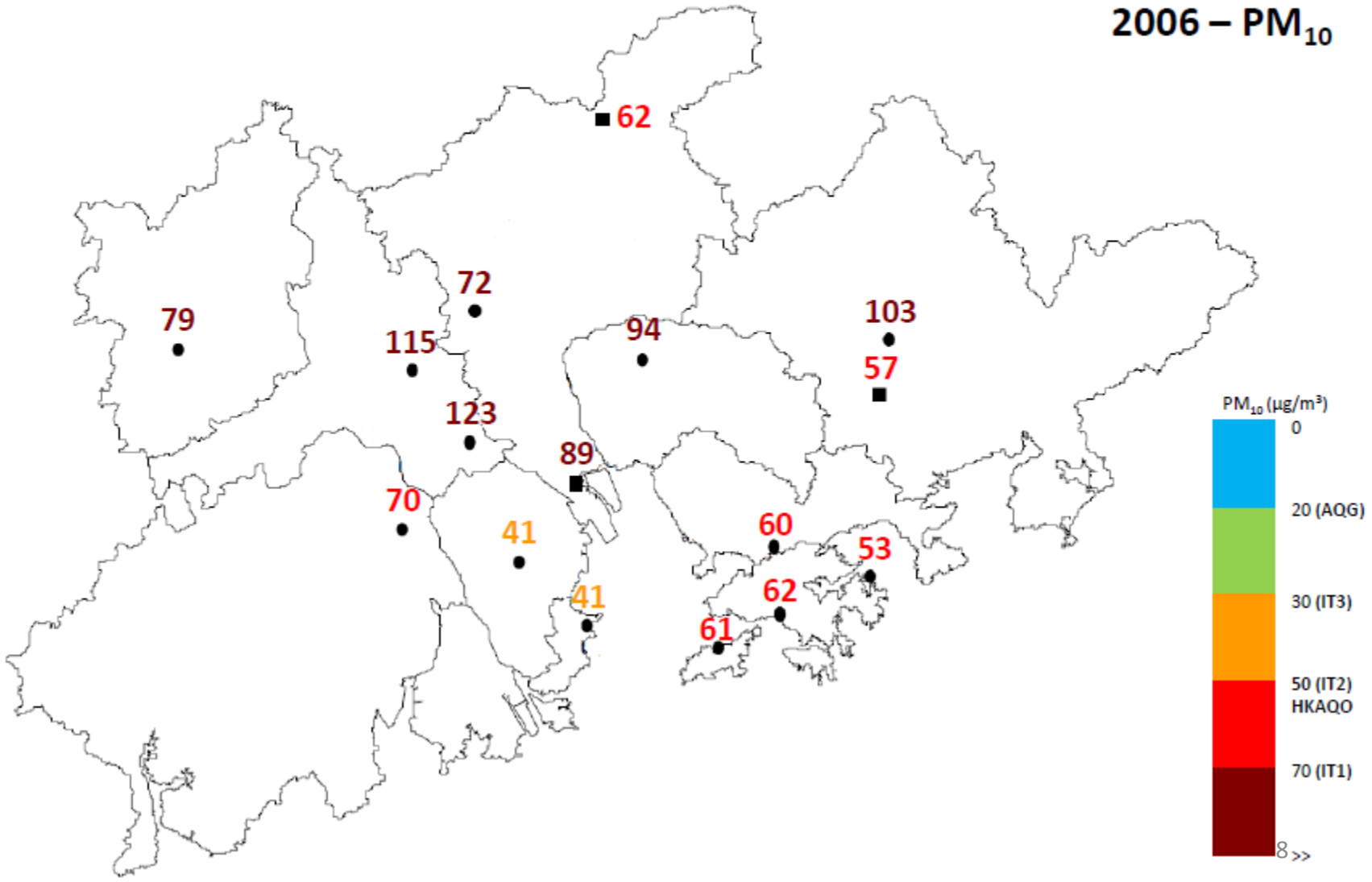
1. LANDSCAPE

- Regional / Local
- Ambient / Roadside

10-year comparison, PRD region

- In general decreasing, PRD higher rate than HK
- West > East
- Rooms for more stringent AQO

PM_{10} Spatial Distribution in PRD



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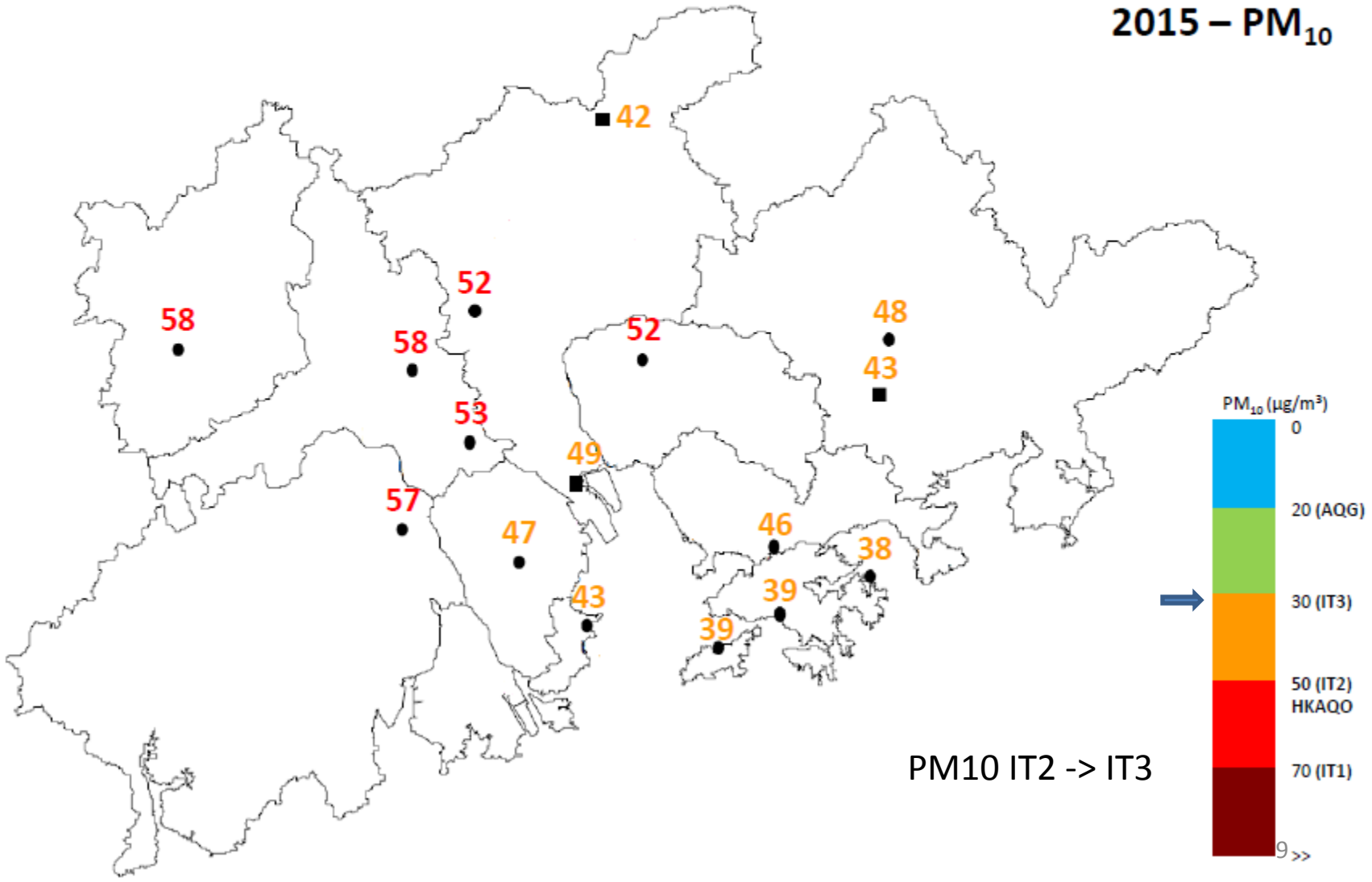
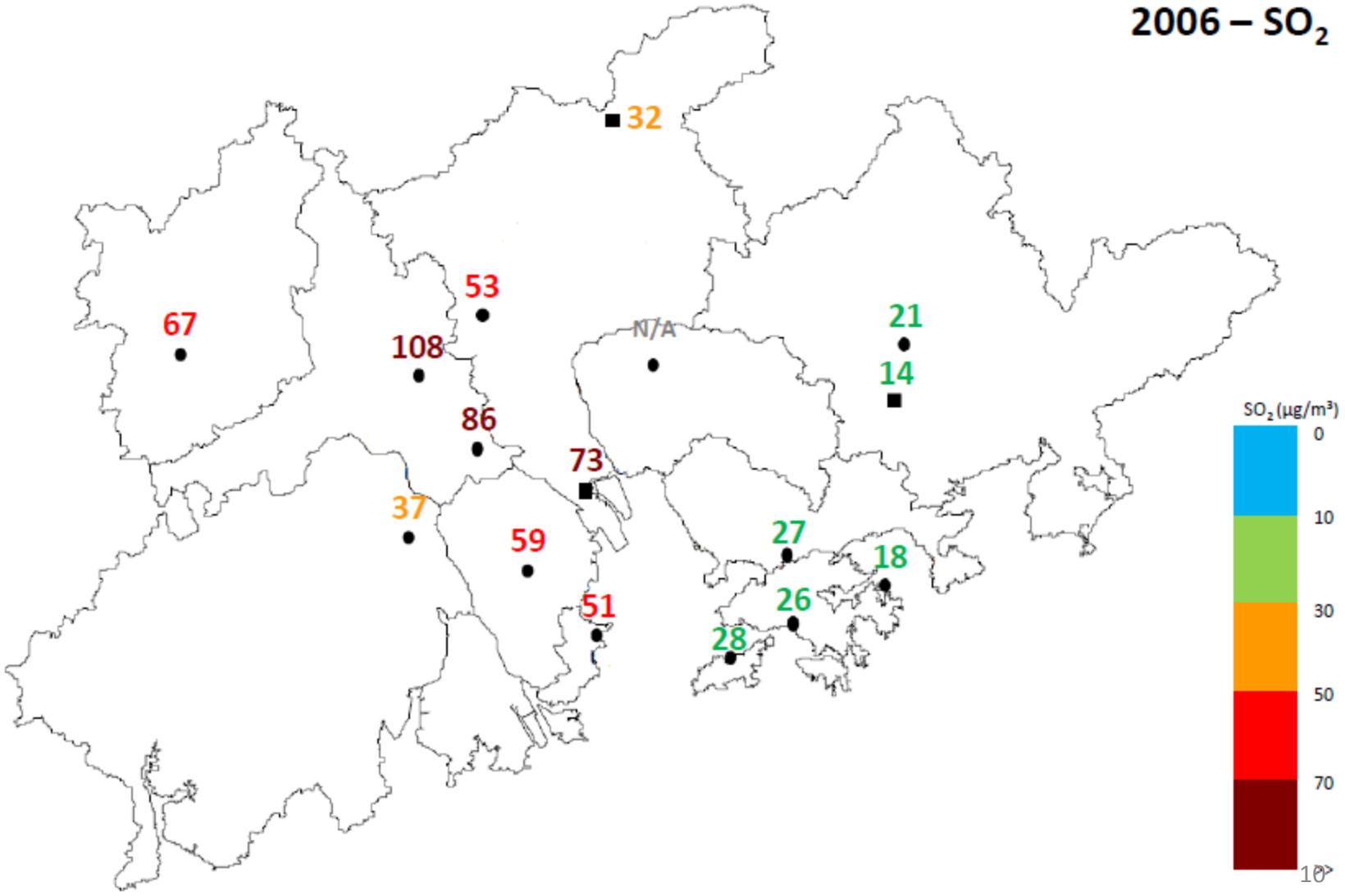
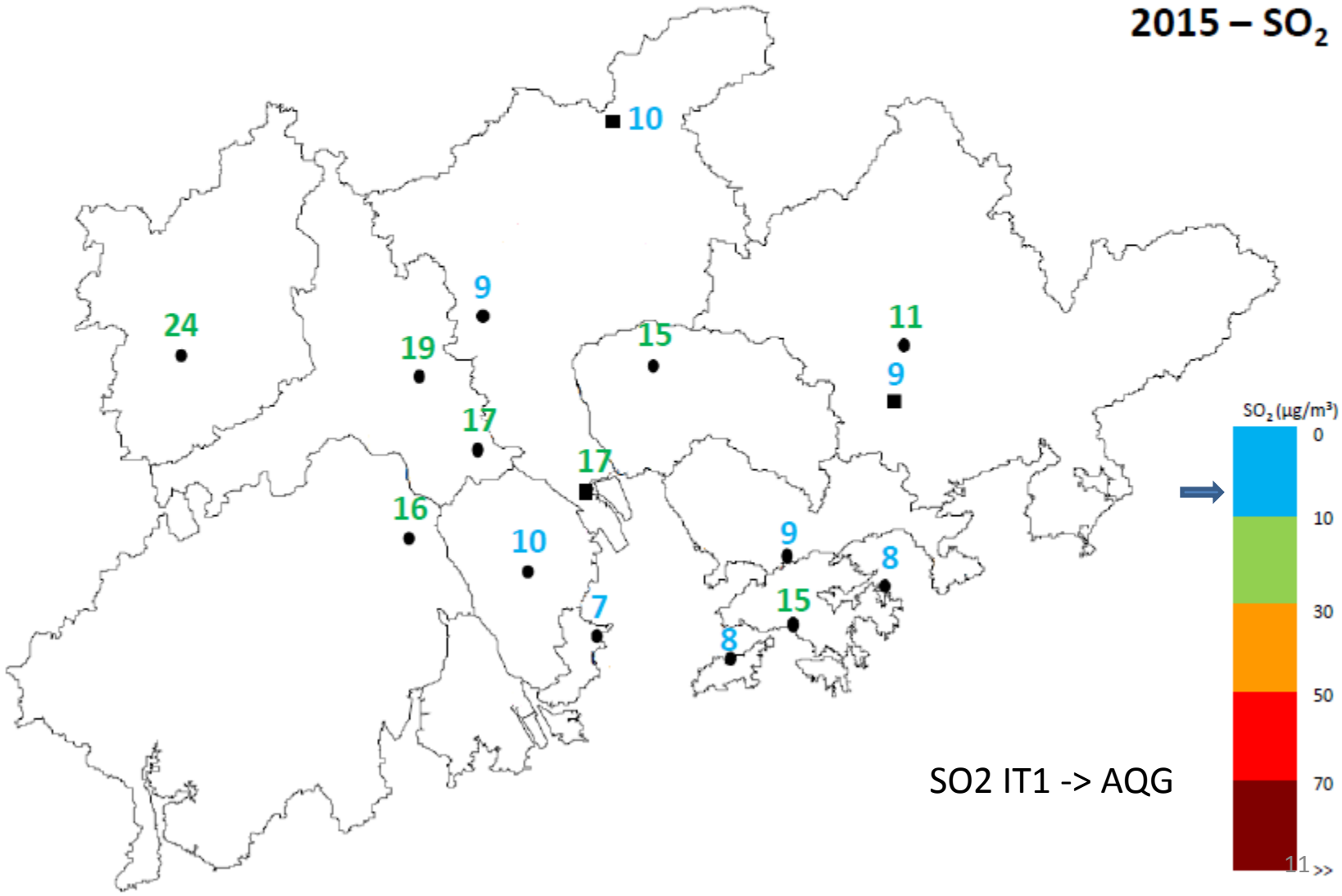


PM10 IT2 -> IT3

SO_2 Spatial Distribution in PRD

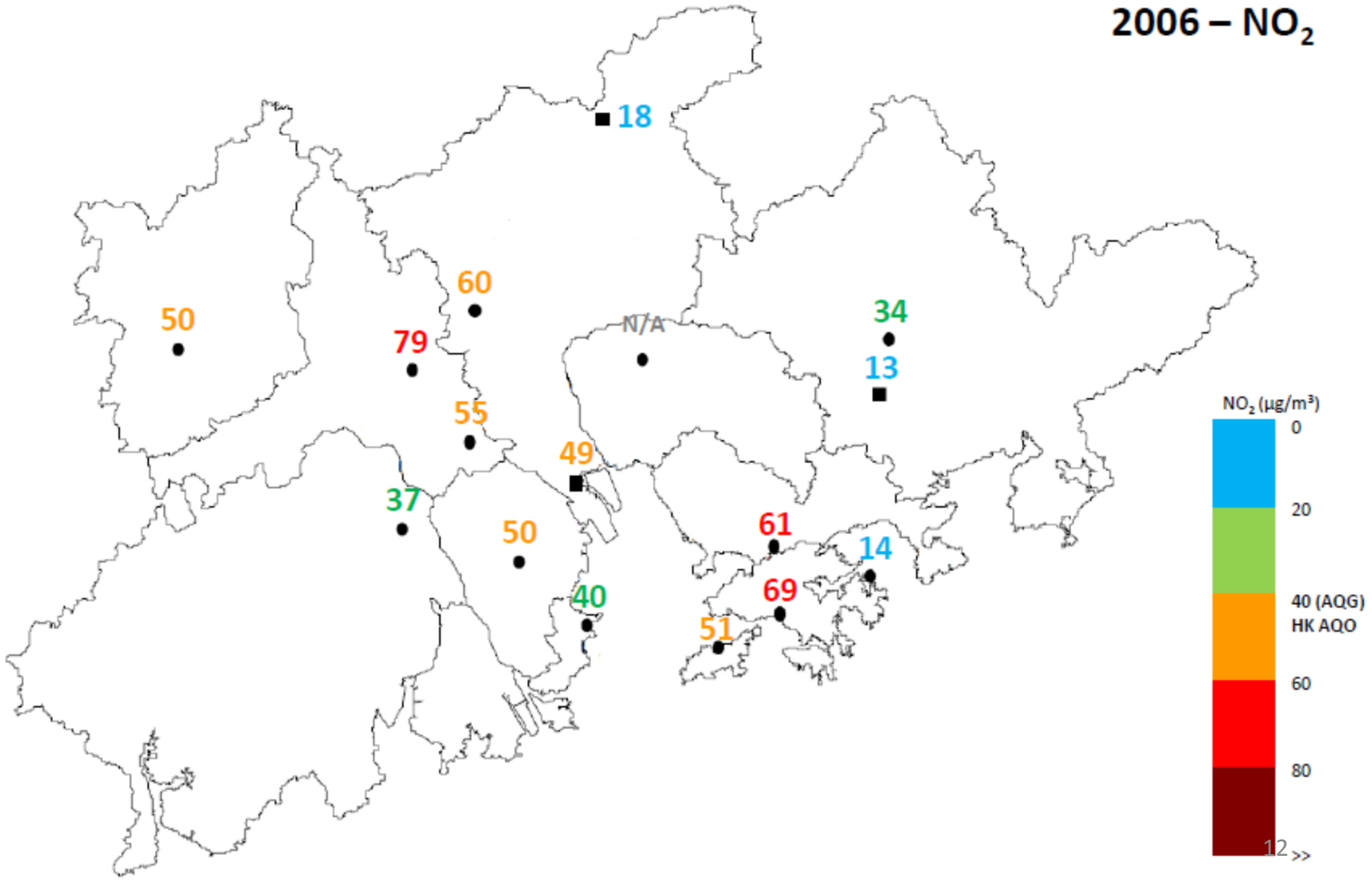


SO_2 Spatial Distribution in PRD

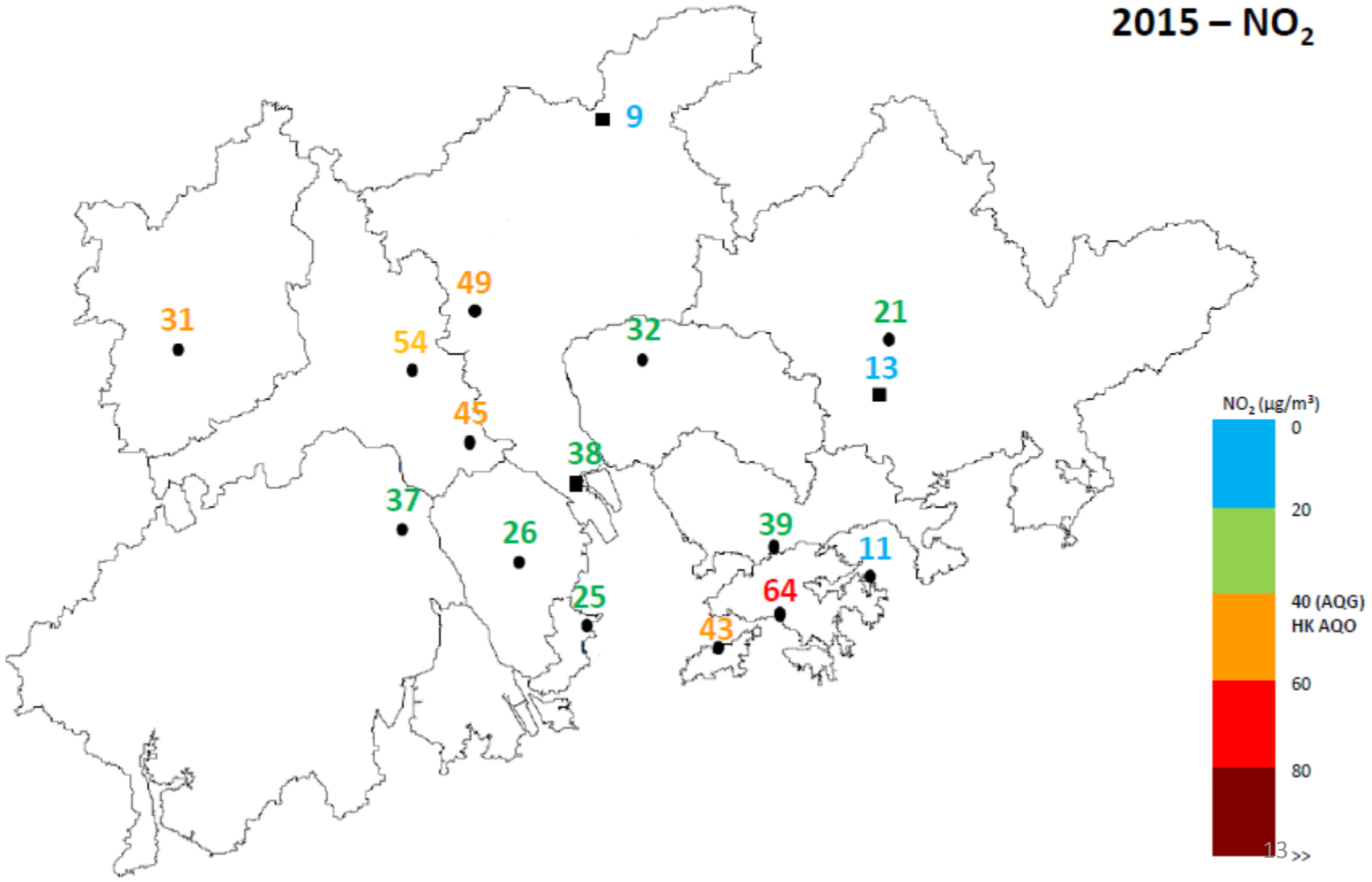


SO2 IT1 -> AQG

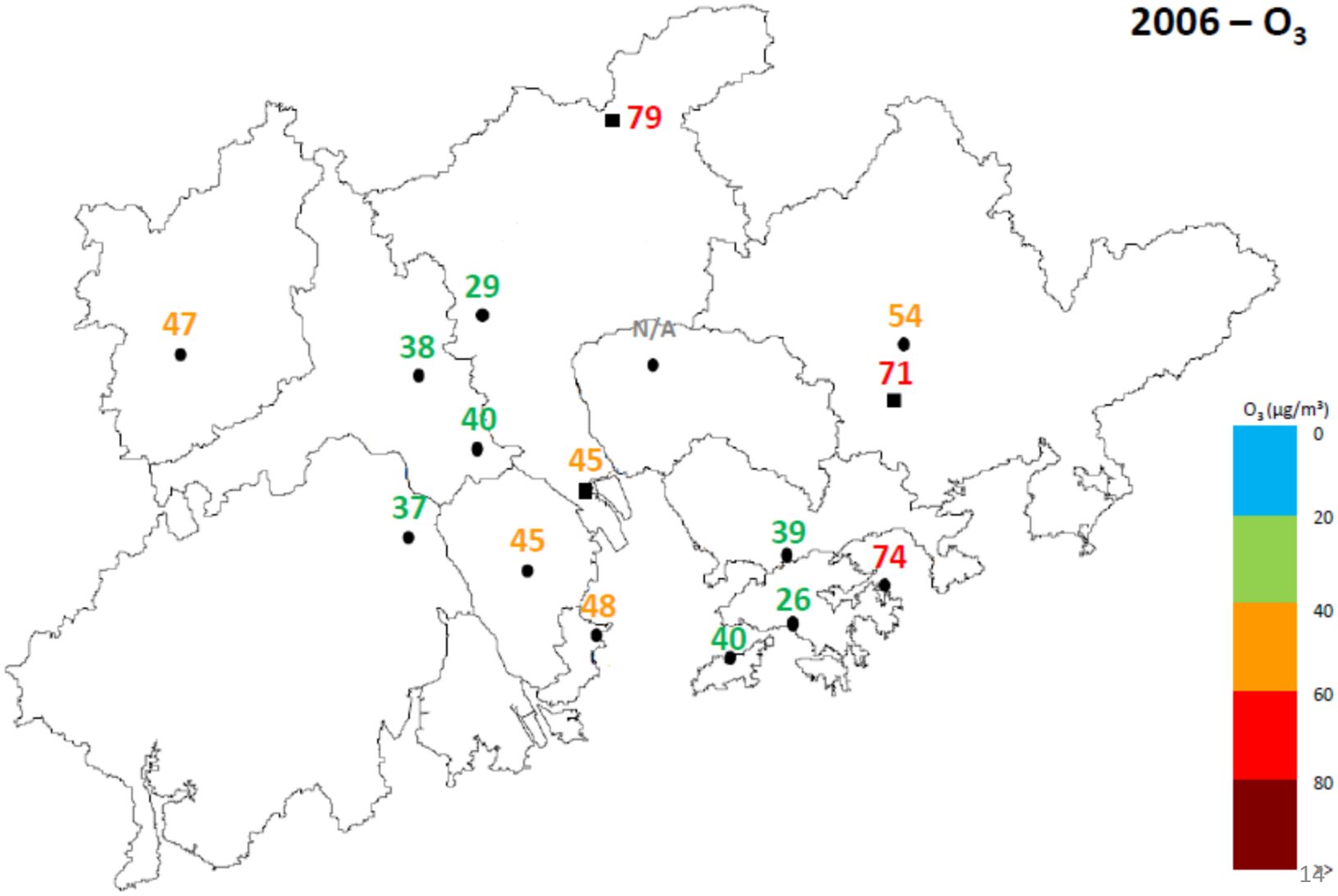
NO_2 Spatial Distribution in PRD



NO_2 Spatial Distribution in PRD



O_3 Spatial Distribution in PRD



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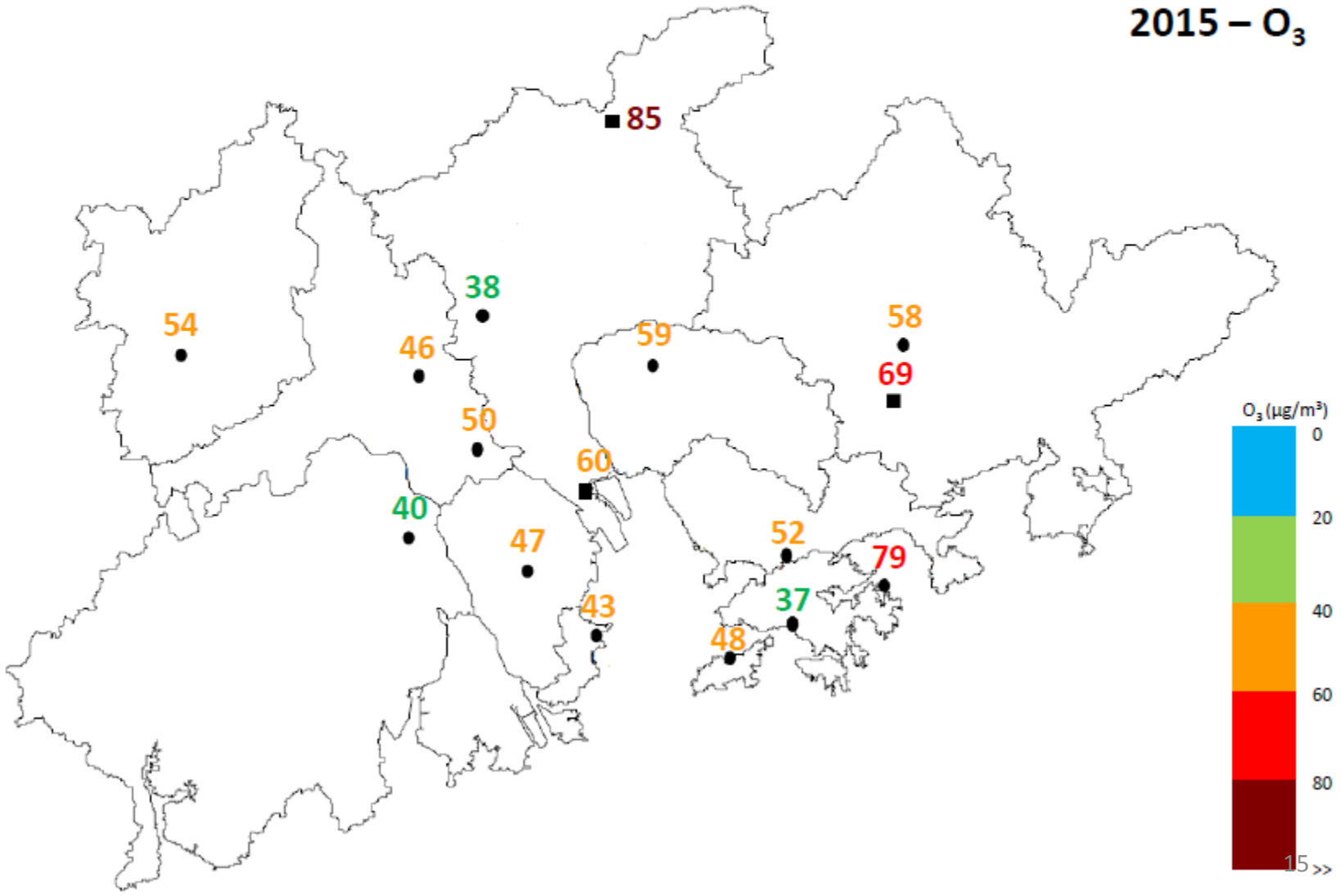
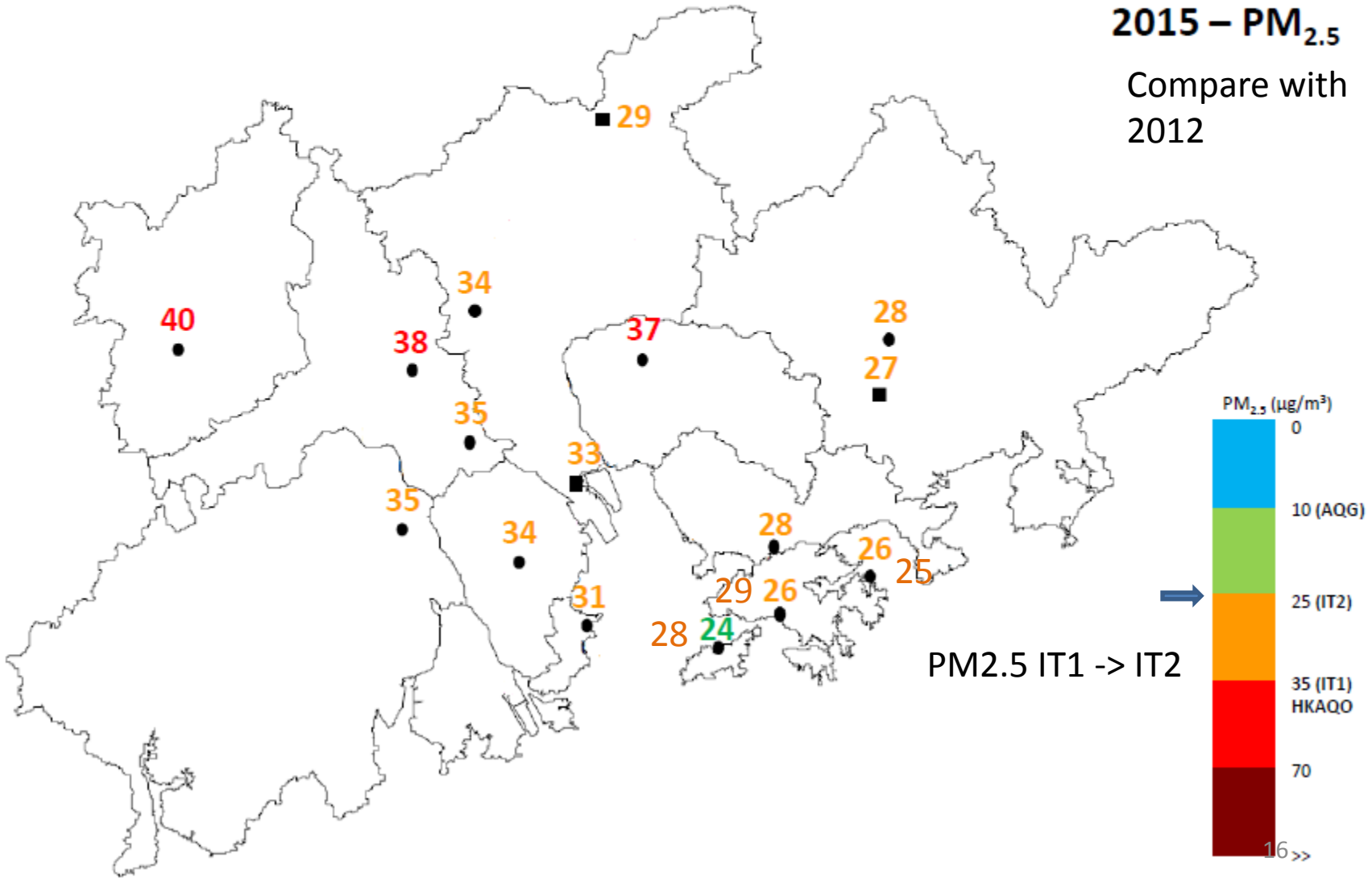


$PM_{2.5}$ Spatial Distribution in PRD

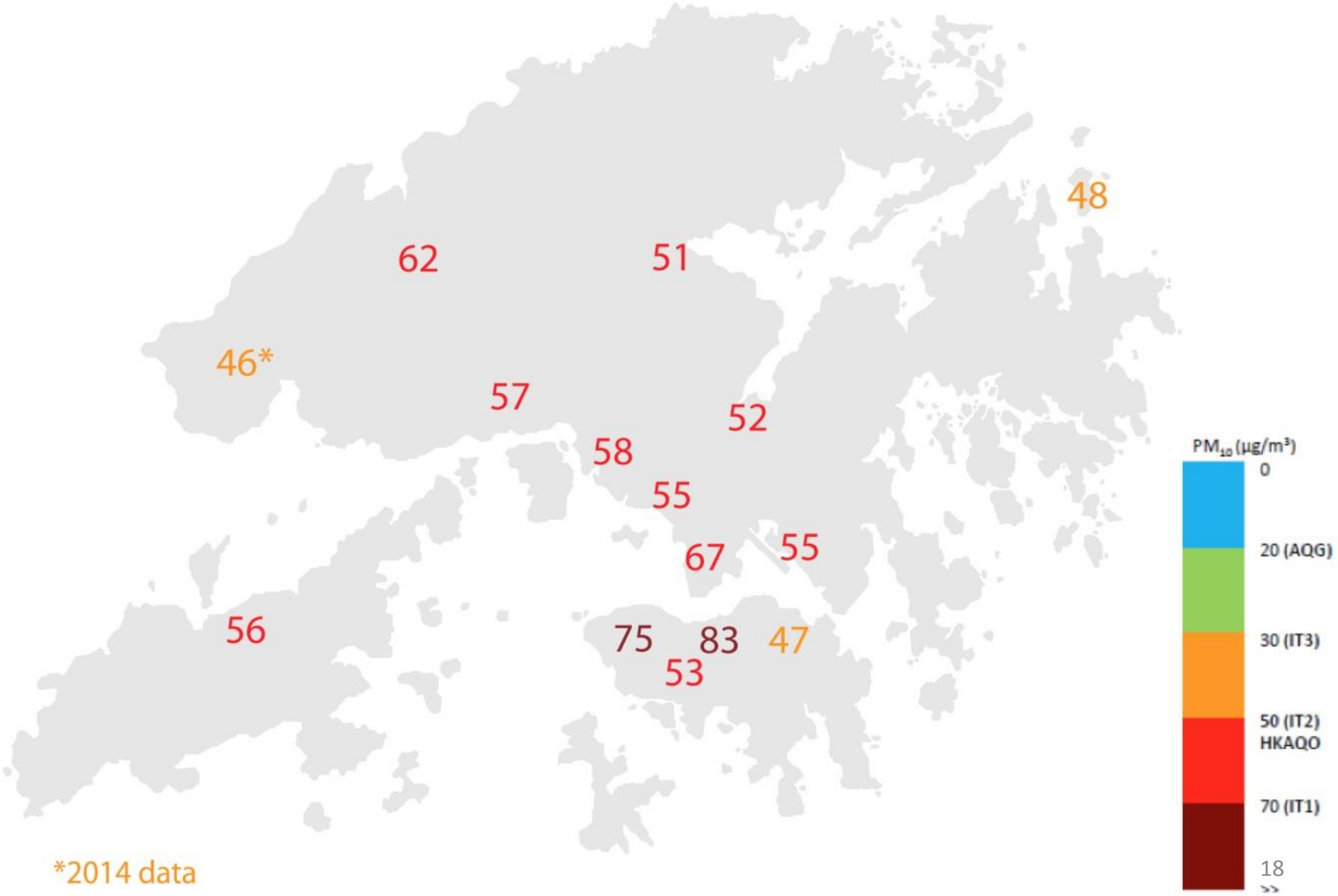


10-year comparison, HK

- In general decreasing
- West > East
- Rooms for more stringent AQO

PM10 Spatial Distribution in HK

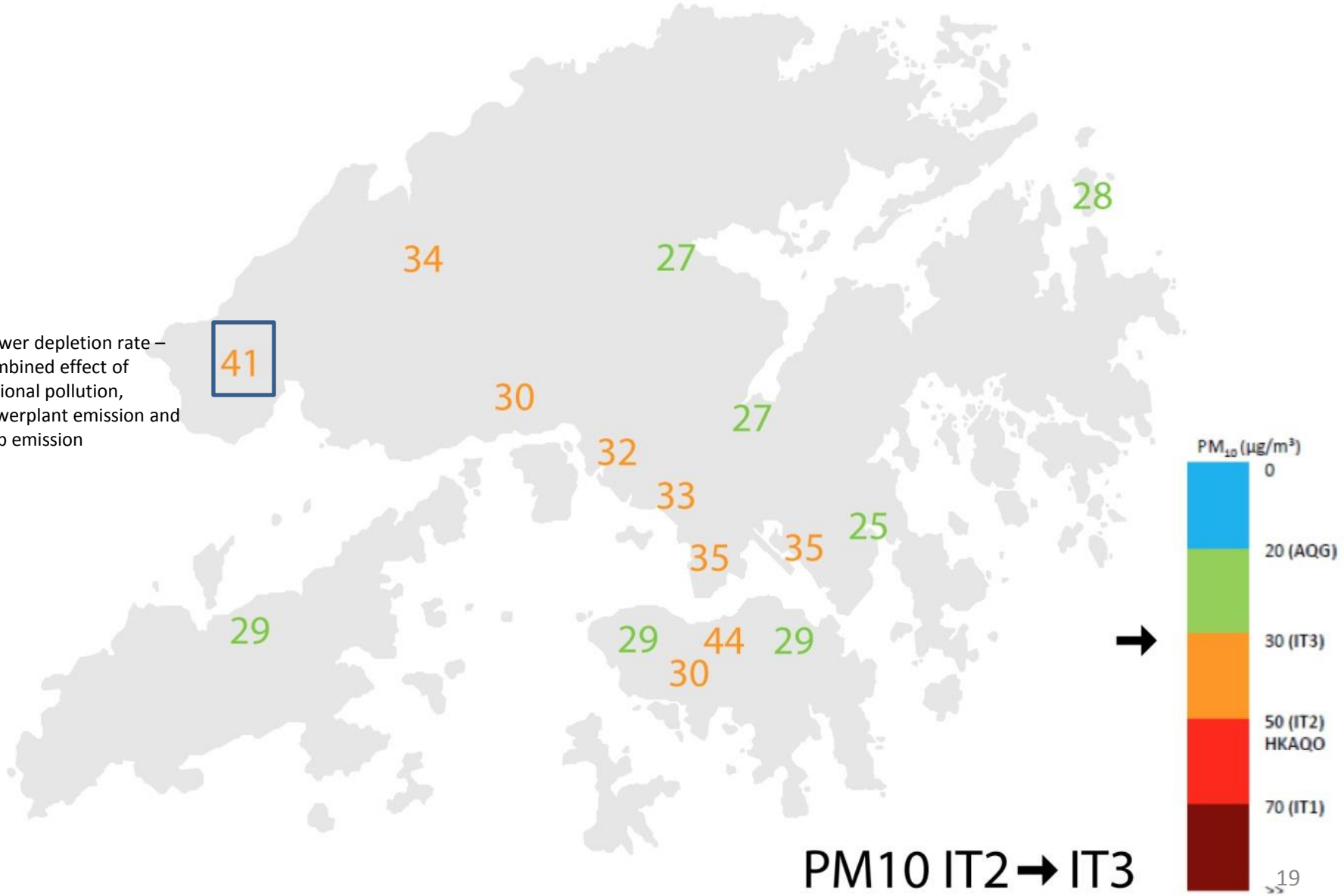
2006



*2014 data

PM10 Spatial Distribution in HK

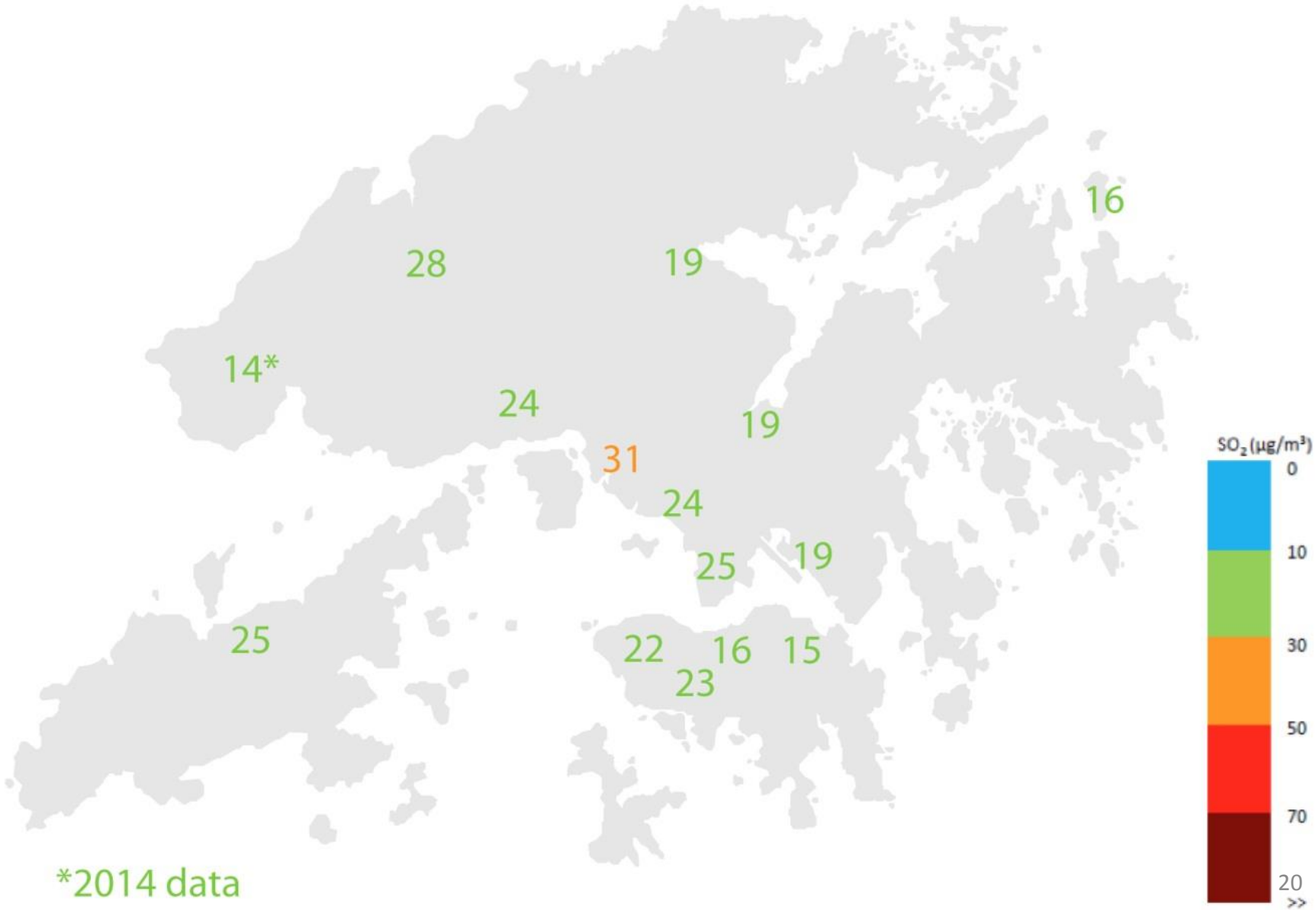
2016



Slower depletion rate – combined effect of regional pollution, powerplant emission and ship emission

SO2 Spatial Distribution in HK

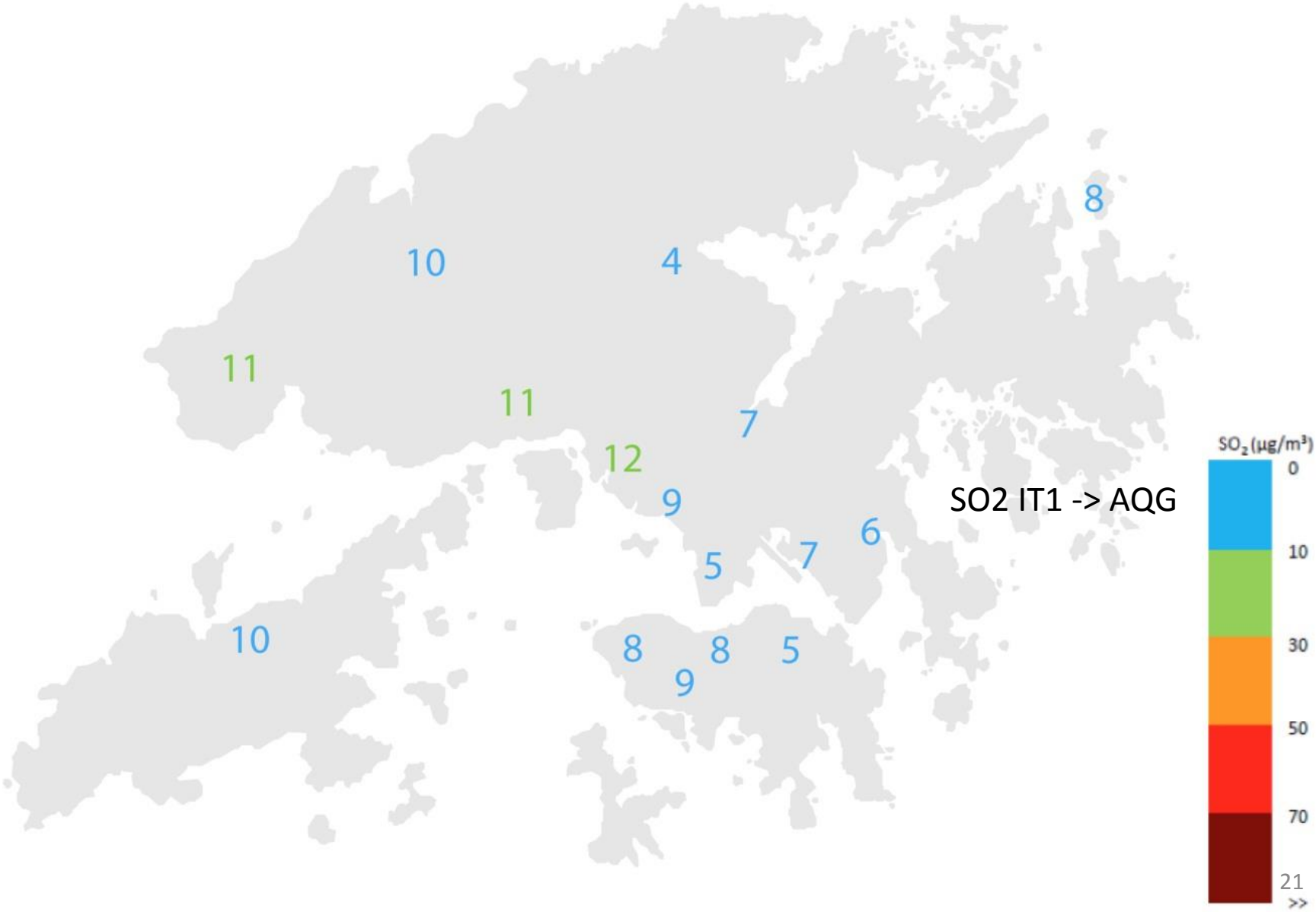
2006



*2014 data

SO2 Spatial Distribution in HK

2016



NO2 Spatial Distribution in HK

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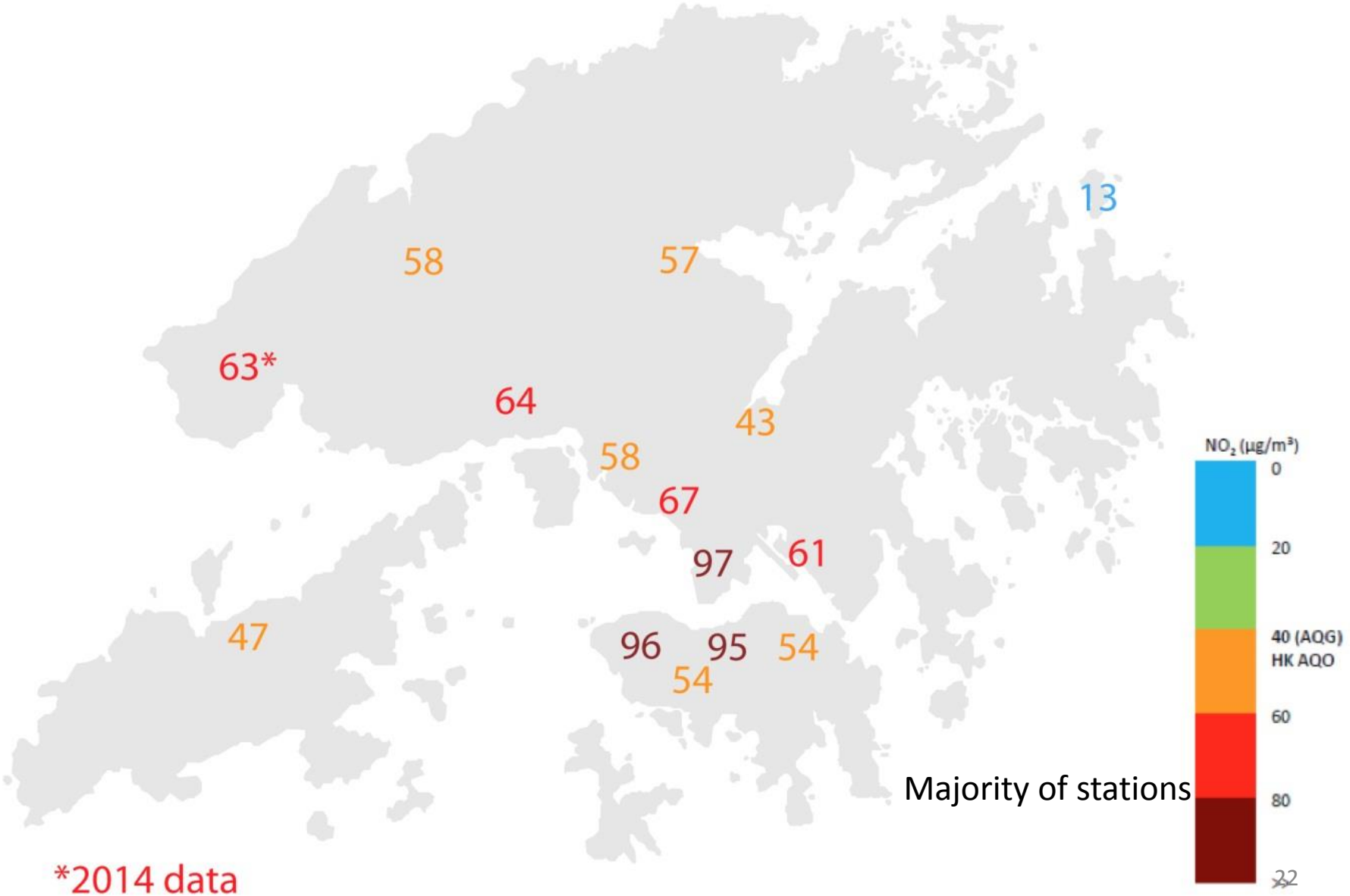
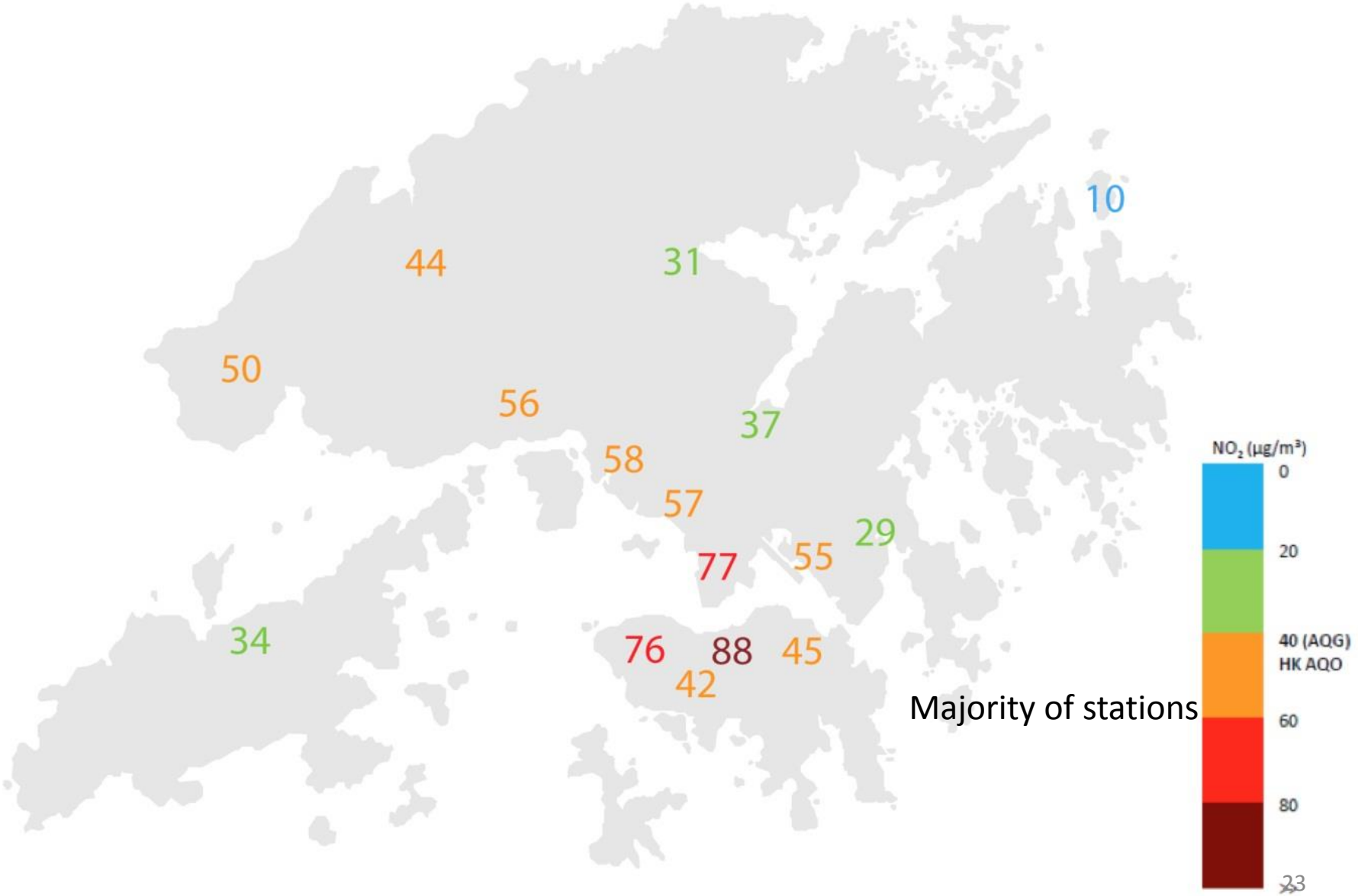


Majority of stations

*2014 data

NO2 Spatial Distribution in HK

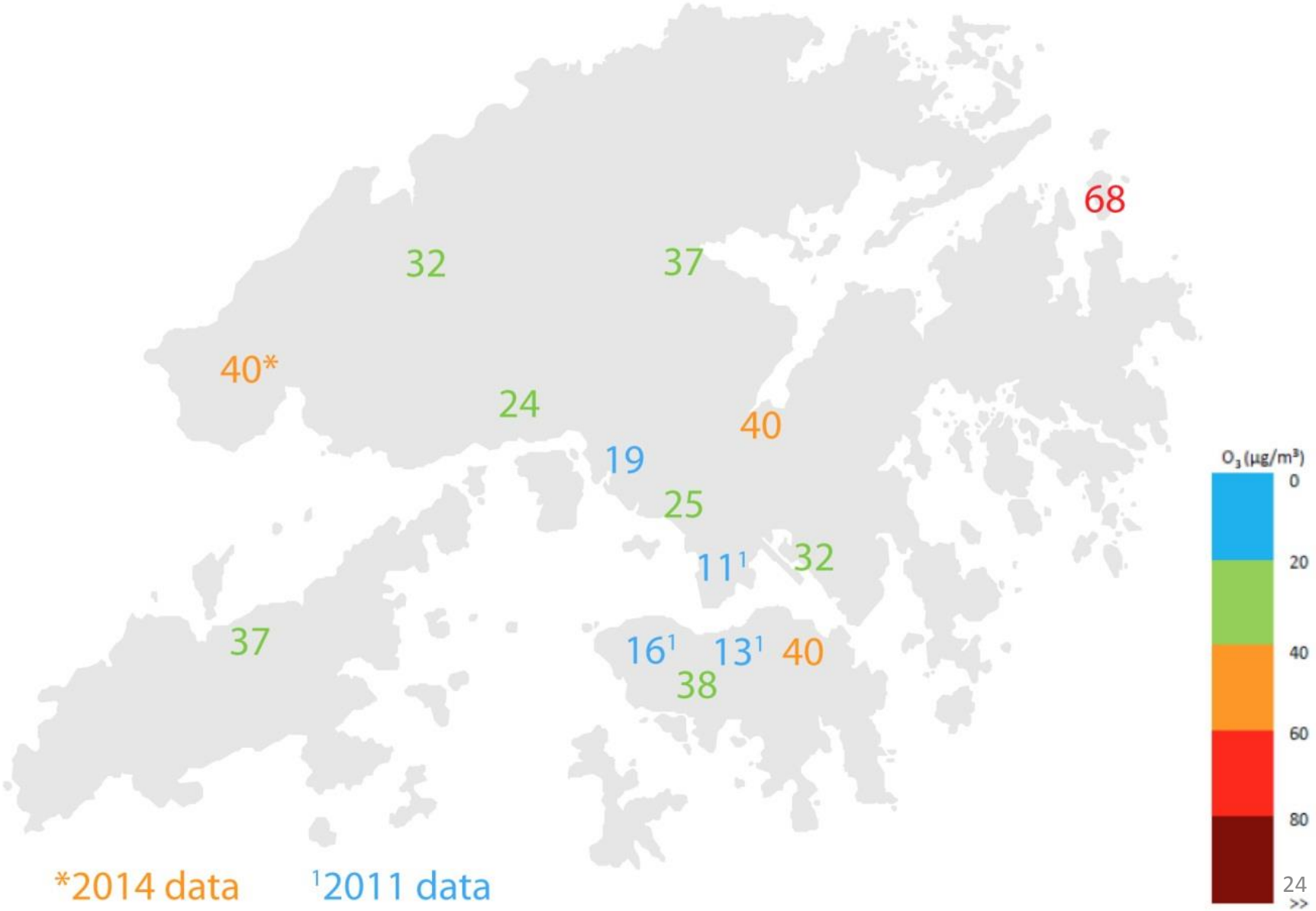
2016



Majority of stations

O3 Spatial Distribution in HK

2006

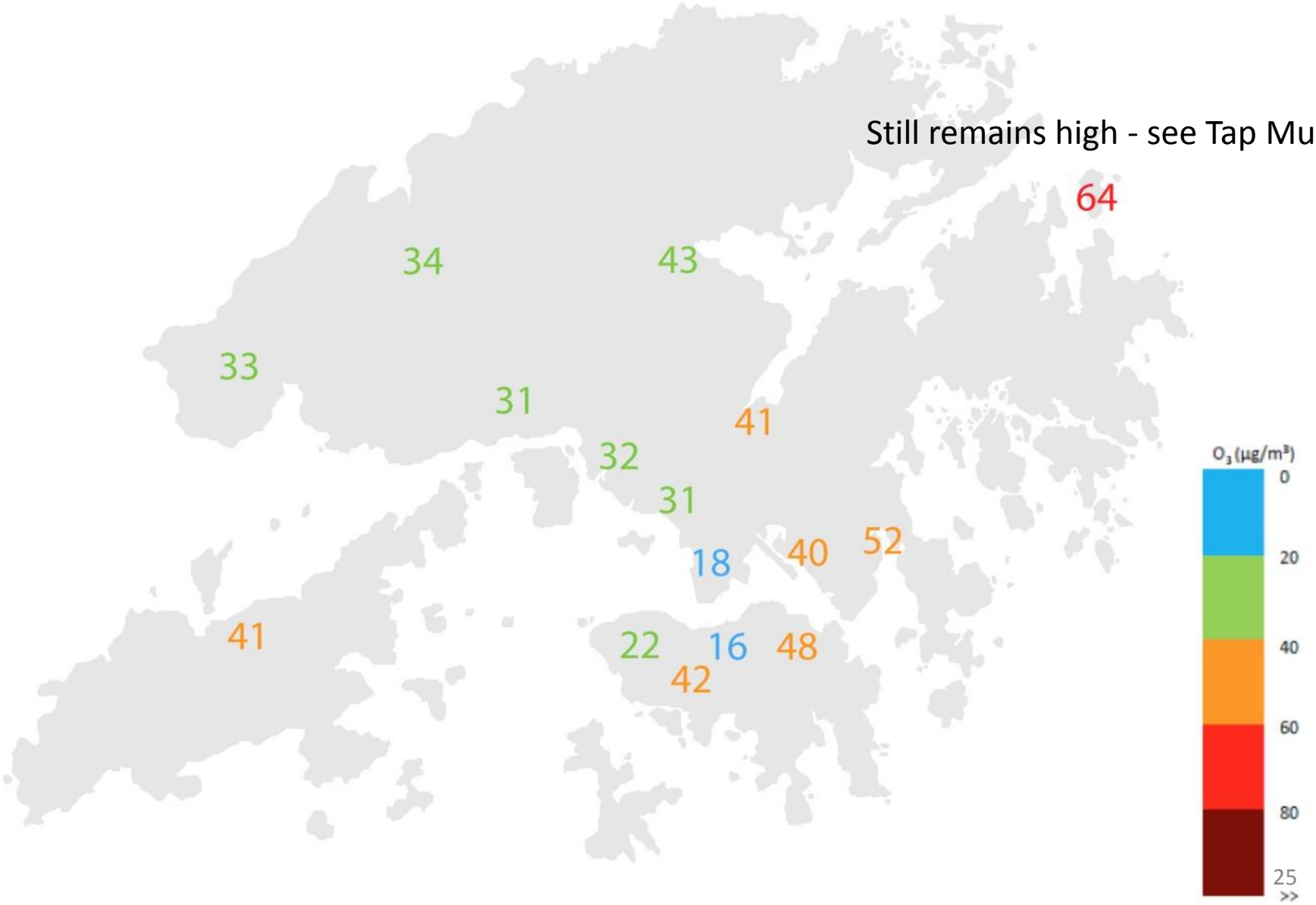


*2014 data [1]2011 data

O3 Spatial Distribution in HK

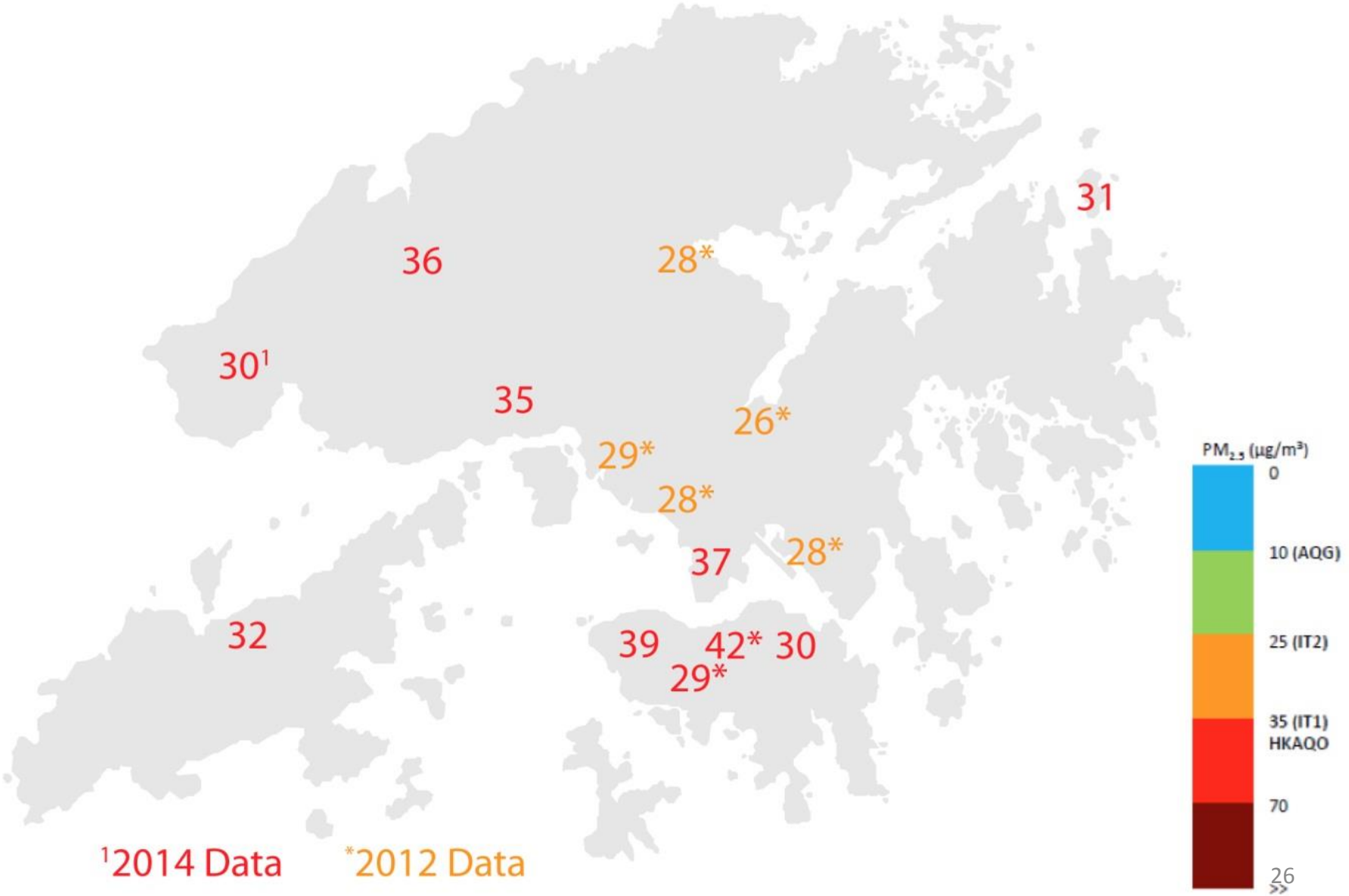
2016

Still remains high - see Tap Mun



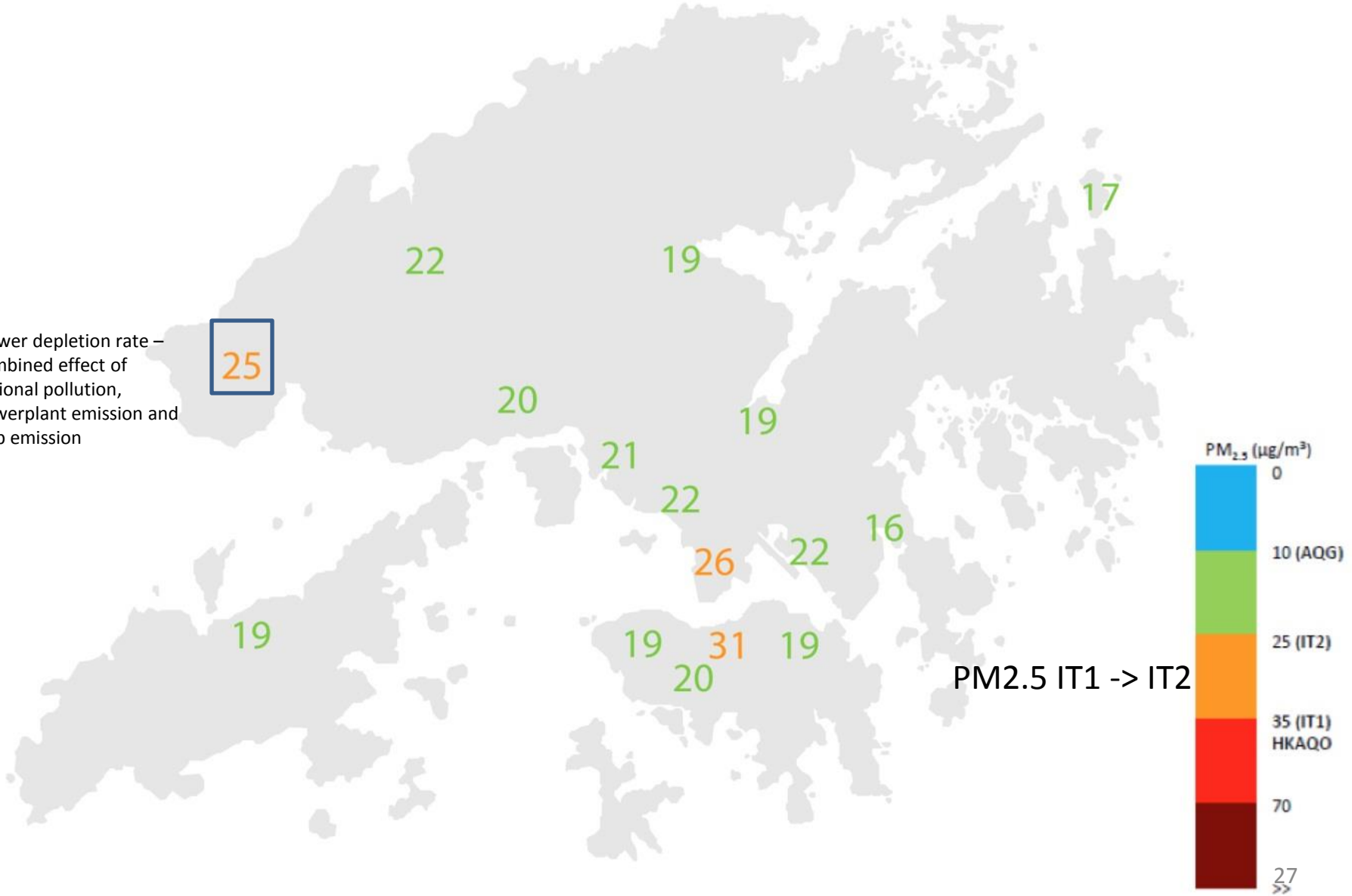
PM2.5 Spatial Distribution in HK

2011



PM2.5 Spatial Distribution in HK

2016



Slower depletion rate – combined effect of regional pollution, powerplant emission and ship emission

More stringent AQO needed

AQO vs WHO AQGs and ITs

Concentration (ug/m^3)		Hong Kong AQO	WHO			
			IT-1	IT-2	IT-3	AQGs
SO_2	10 min	500		--		**500**
	24 hr	125	**125**	50		20
RSP (PM_{10})	24 hr	100	150	**100**	75	50
	Annual	50	70	**50**	30	20
FSP ($PM_{2.5}$)	24 hr	75	**75**	50	37.5	25
	Annual	35	**35**	25	15	10
NO_2	1 hr	200		--		**200**
	Annual	40		--		**40**
O_3	8 hr	160		**160**		100
CO	1 hr	30,000		--		**30,000**
	8 hr	10,000		--		**10,000**
Pb	Annual	0.5		--		**0.5**

2. SPATIAL & DIURNAL

- Spatial distribution of air pollution
- Diurnal pattern of air pollution

Spatial distribution – bad air hours in a day

- The analysis gives the total number of hours with bad air quality (concentration exceeds WHO or Hong Kong Standard).
- Annual average cannot reflect the fluctuating nature of pollutant concentration across a day.
- West > East
- Pollution **blackspots**– Tuen Mun, Kwai Chung, Causeway Bay, Mong Kok and Central

PM10

- Over 75% time in a day PM10 not in safe level: **Causeway Bay, Tuen Mun, Mong Kok, Kwun Tong, Kwai Chung**

PM2.5

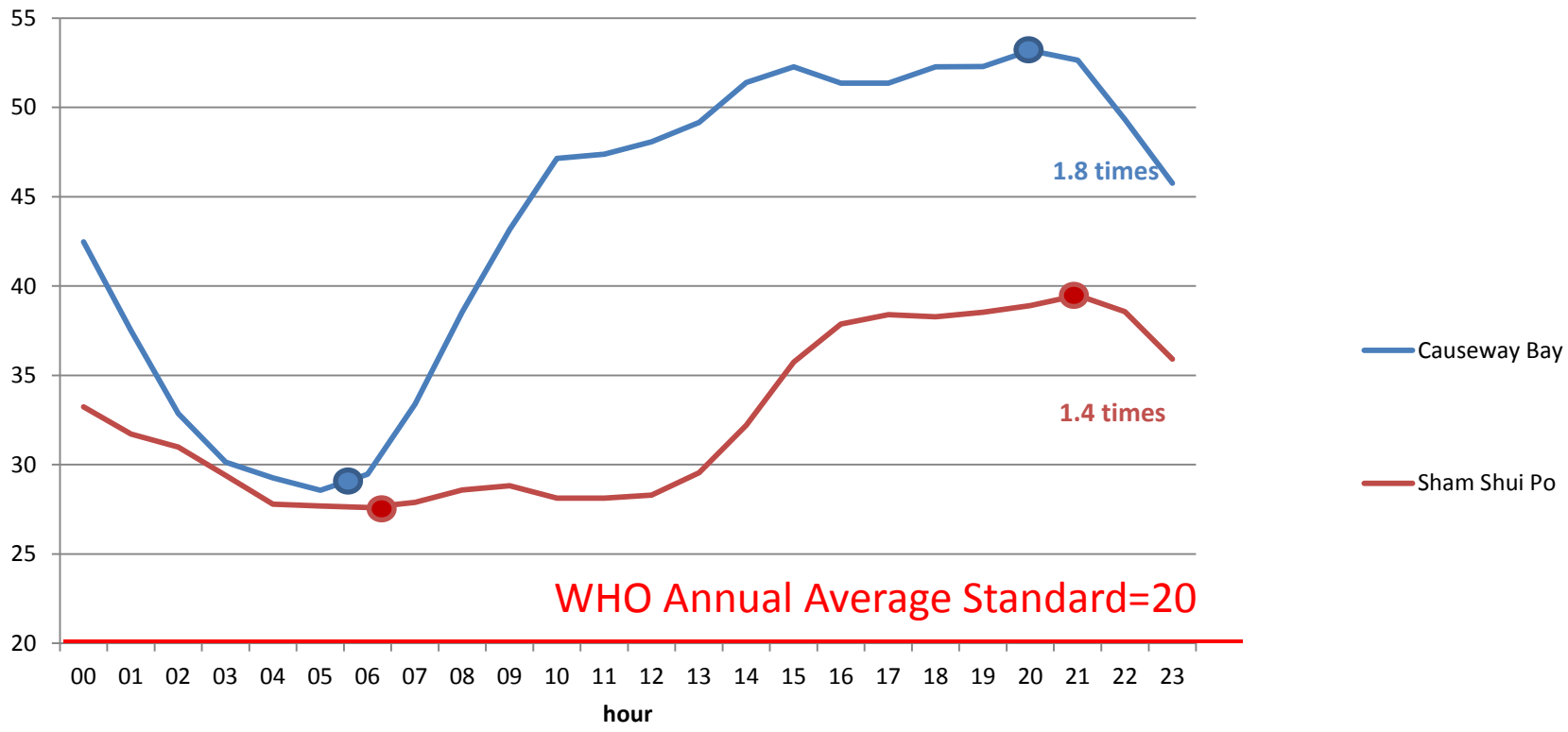
- Over 75% time in a day PM2.5 not in safe level: **Nearly all stations*** except Tung Chung, Shatin, Eastern District

NO2

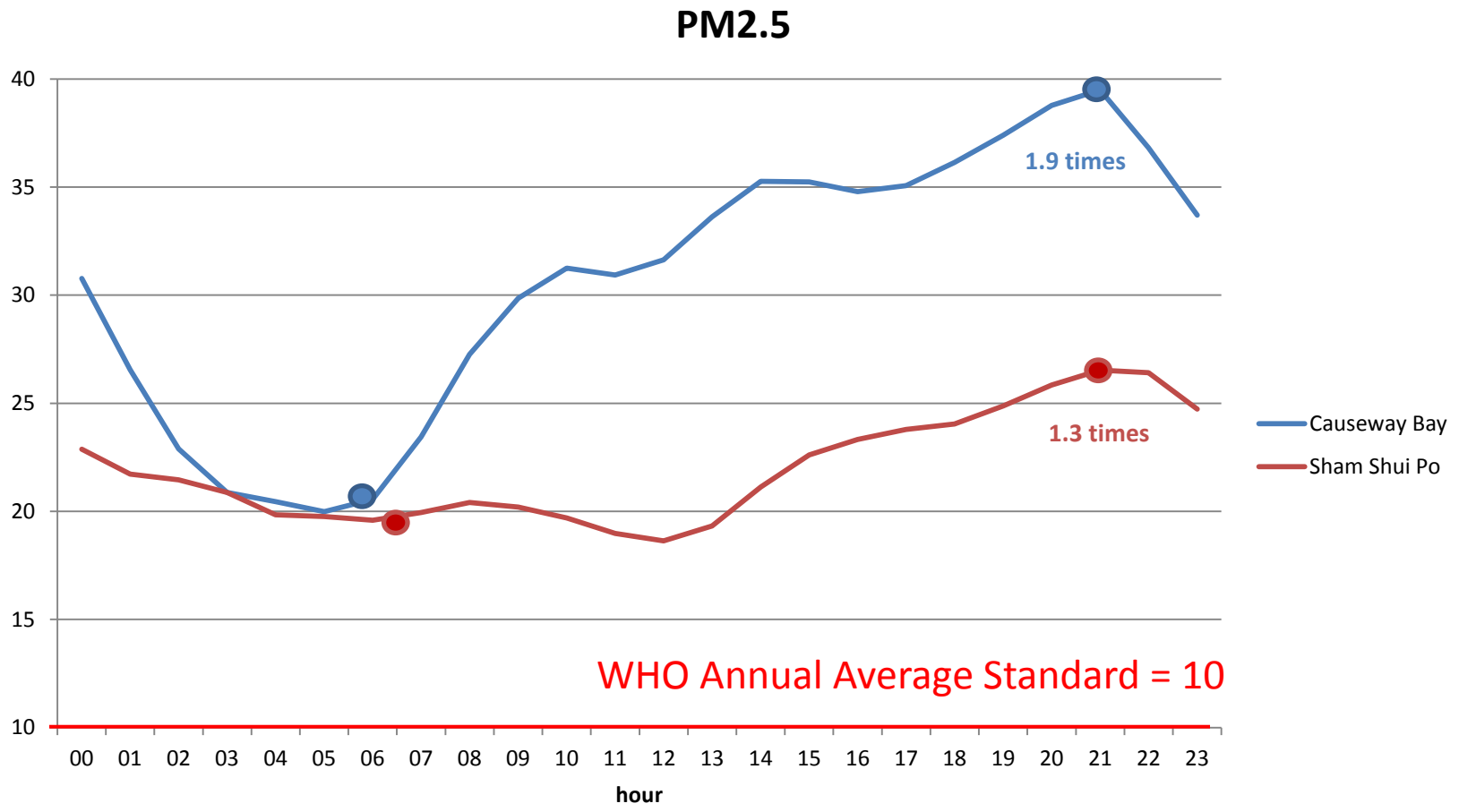
- Over 75% time in a day NO2 not in safe level: **Causeway Bay, Mong Kok, Central**

Let’s take a closer look.

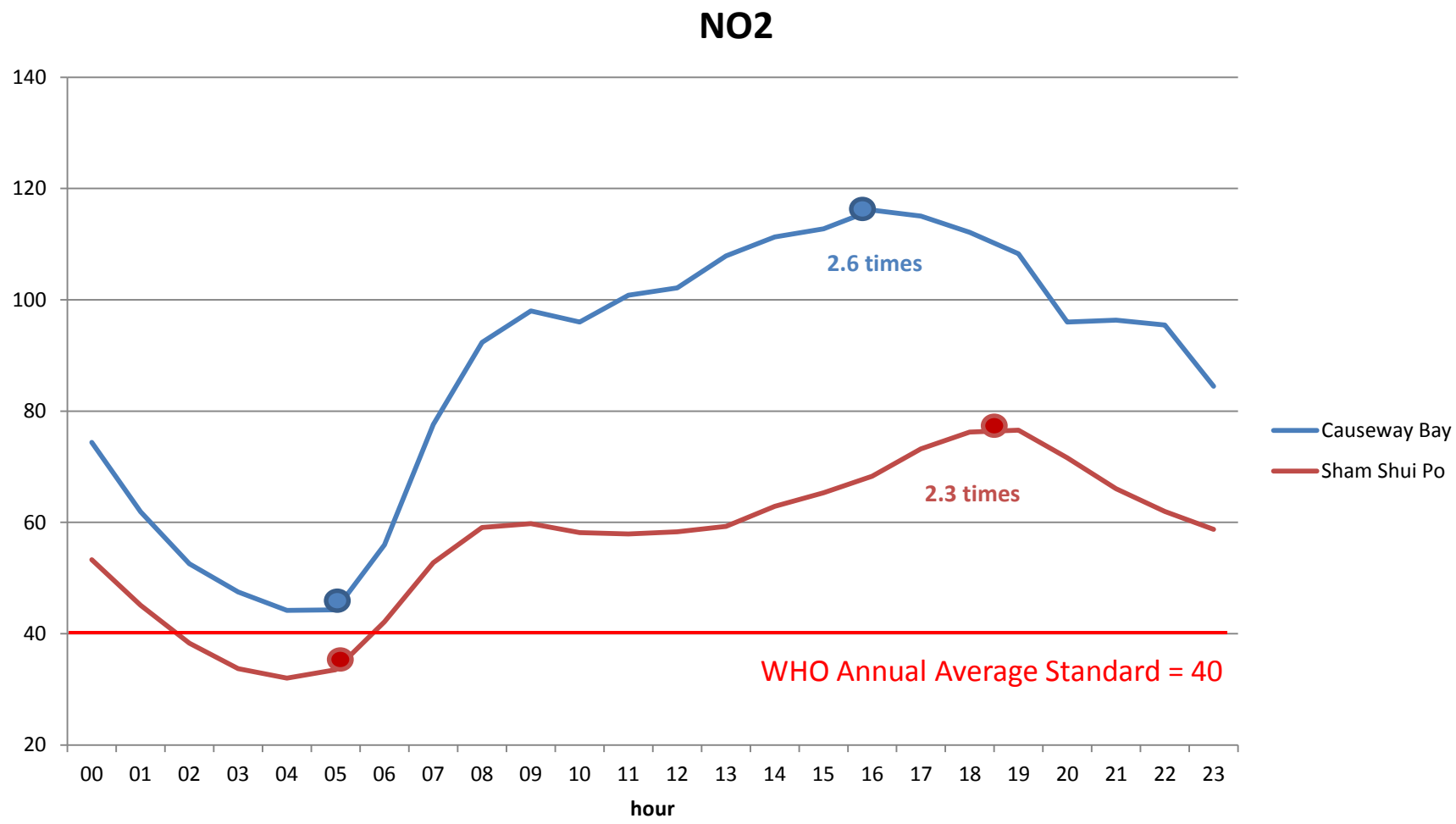
Diurnal Variation – PM 10



Diurnal Variation – PM 2.5



Diurnal Variation – NO2



Diurnal Variation - concentration

- Pollutants level usually high when car activities starts after morning / when sun level is high in the afternoon

- The peak could rise as much as **1.3-1.9 times** for PMs; and even more **2.3-2.6 times** for NO2

- The high variation reflects the need for a more refined reporting mechanism for public to decide next action

Diurnal Variation – health impacts

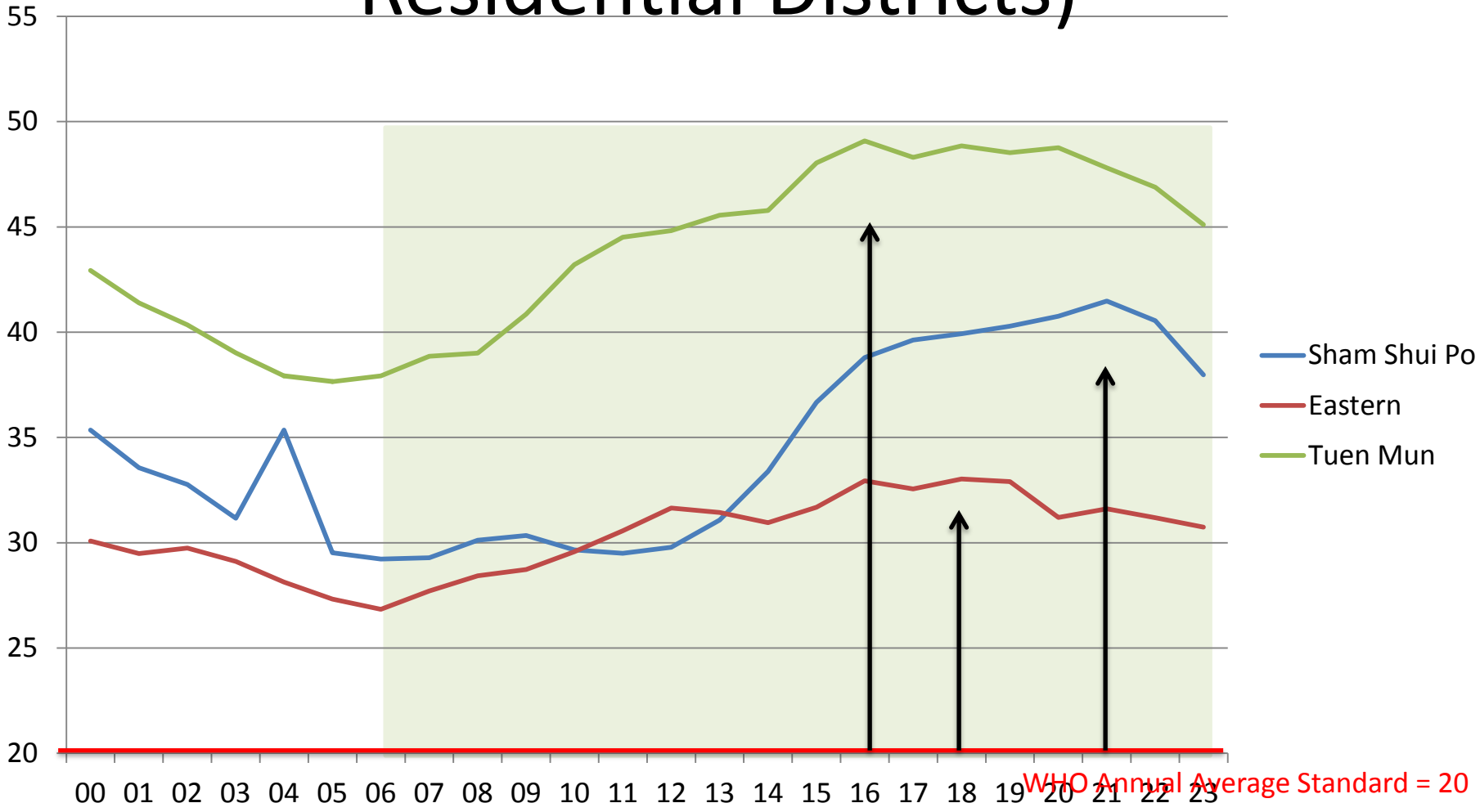
- High level of air pollution caused by heavy human activities, i.e. traffic (as shown by peak hour) varies across districts

- Air pollution: West > East
- Health impacts: West > East

- E.g. Hospital admissions for cardiovascular diseases and respiratory diseases, Incidence of asthma symptoms

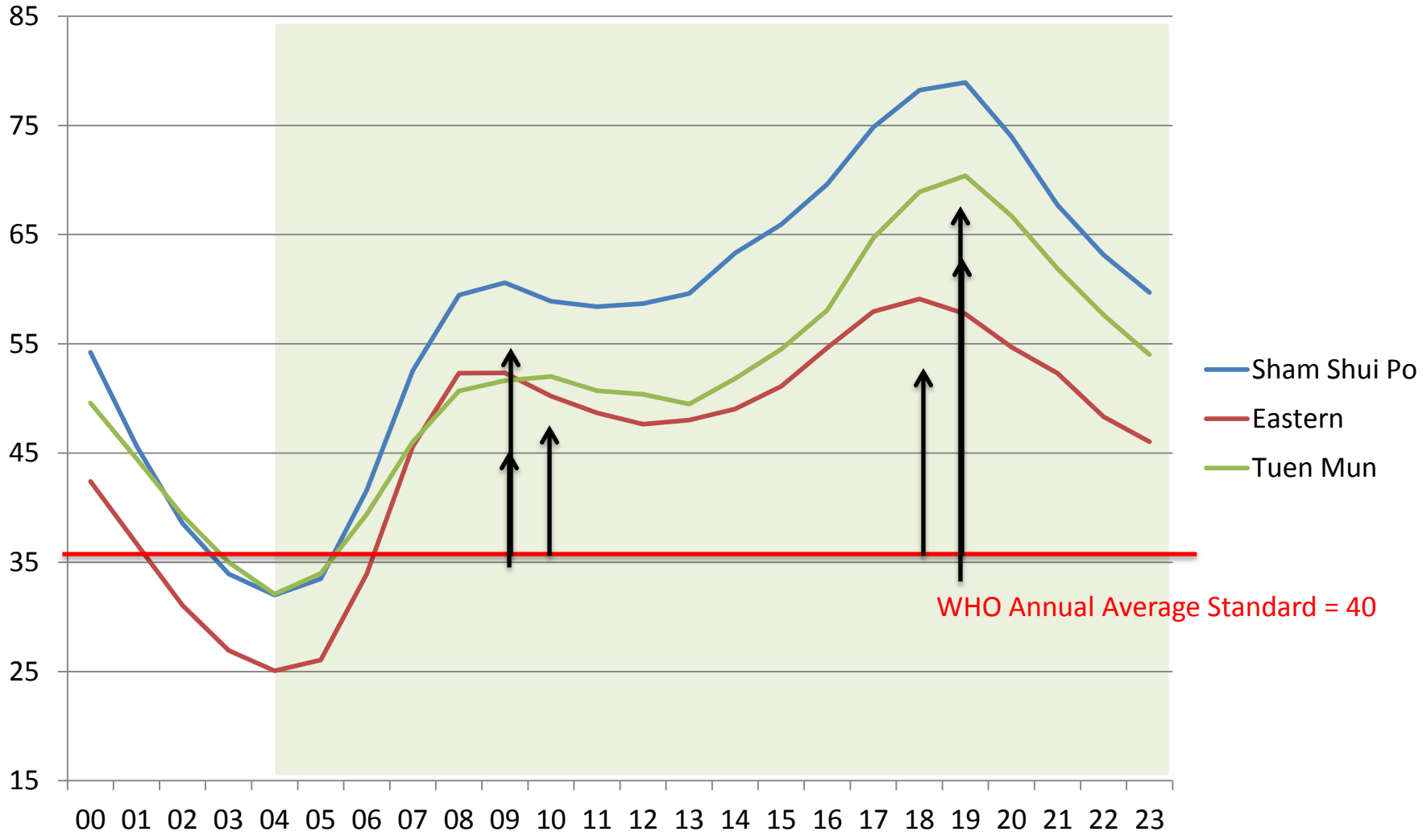
- More dispersed pattern for roadside stations indicates higher adverse health impacts caused by higher level of human activities

Diurnal Variation – PM 10 (Mainly Residential Districts)



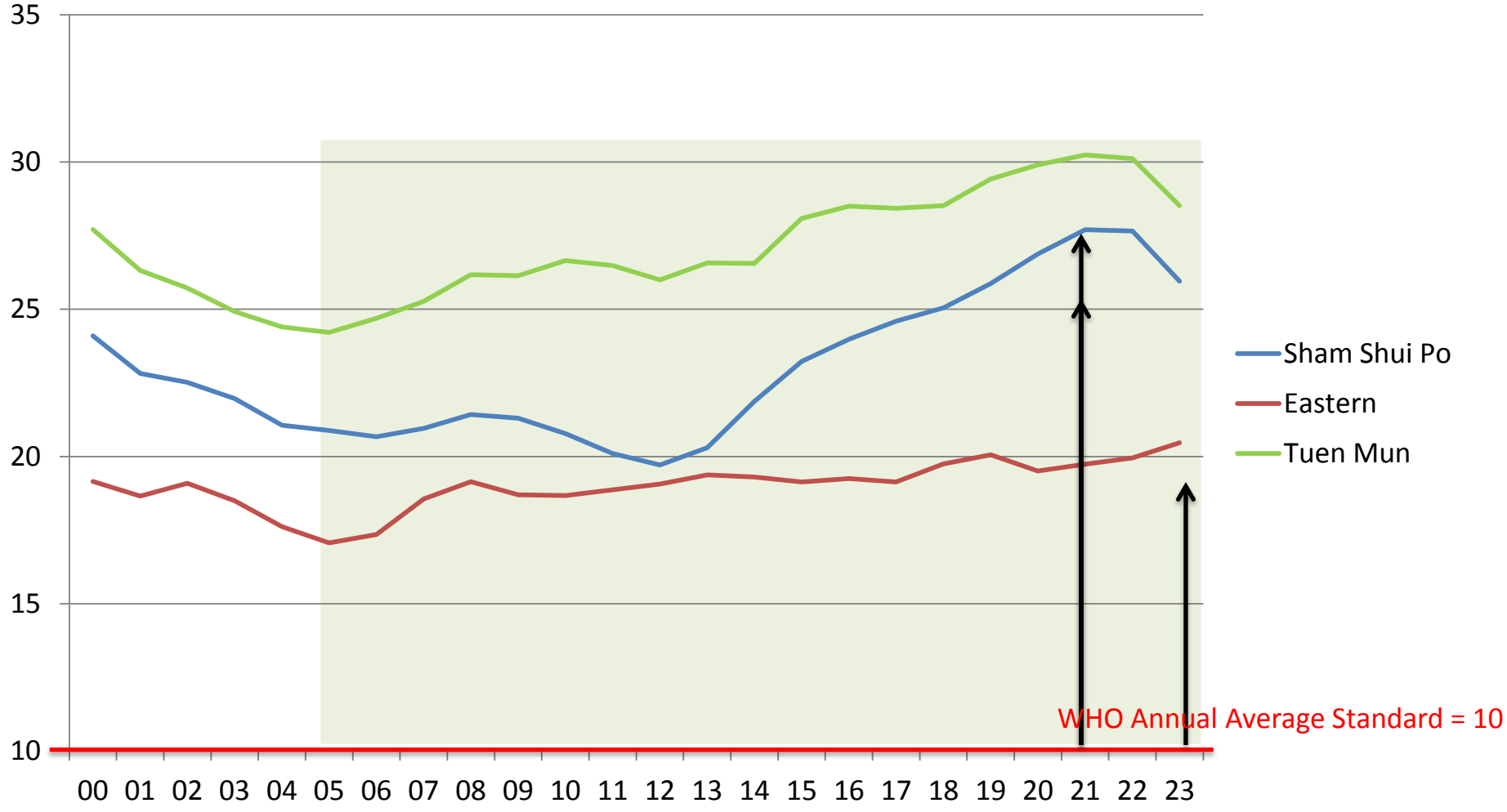
Incidence of asthma symptoms in asthmatic children aged 5-19 years:
SSP (+6.0%) Eastern (+3.6%) Tuen Mun (+8.1%)

Diurnal Variation – NO2 (Mainly Residential Districts)



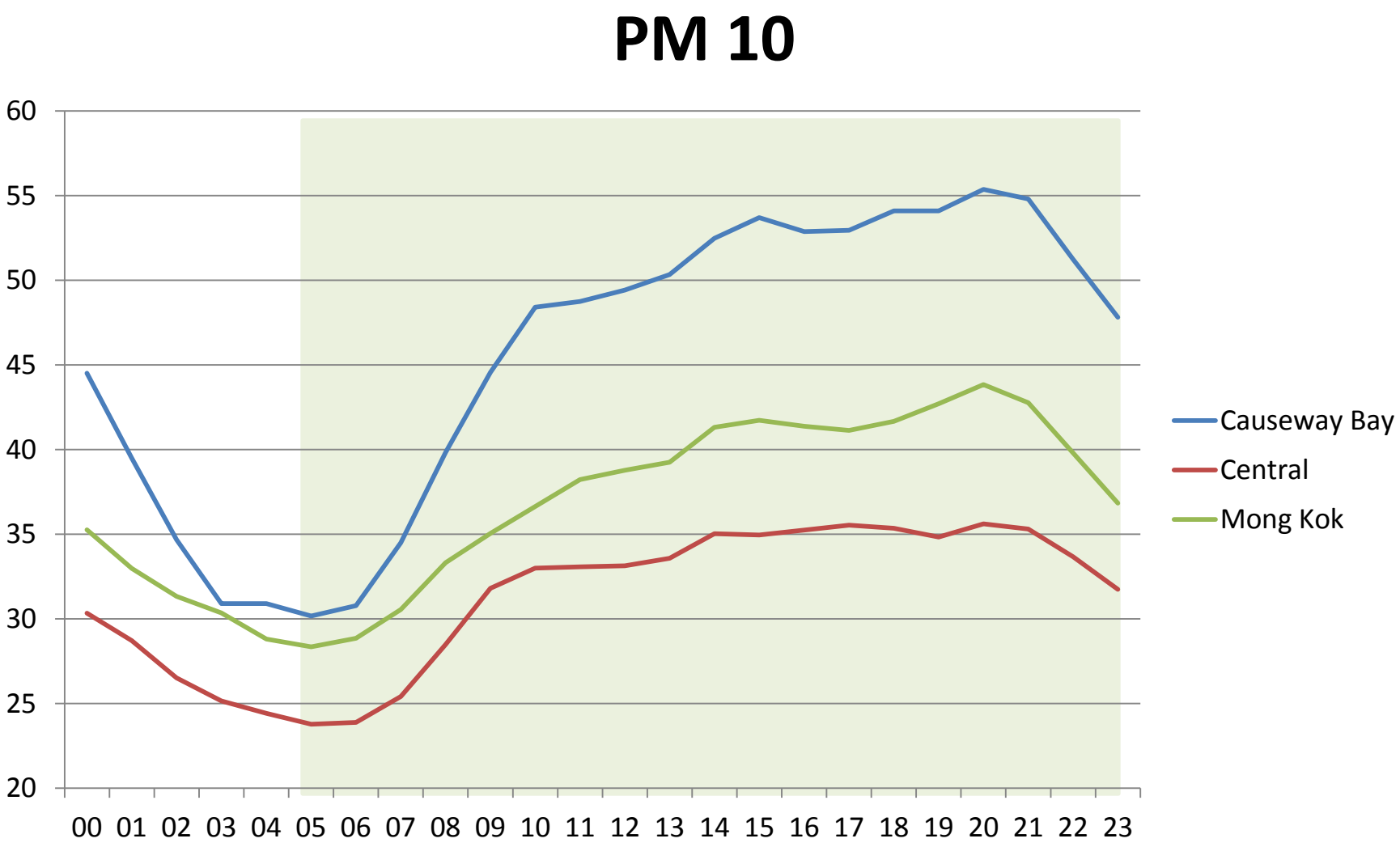
Mortality, all (natural) causes, all ages: SSP (+1.1%) Eastern (+0.5%) Tuen Mun (+0.8%)

Diurnal Variation – PM 2.5 (Mainly Residential Districts)

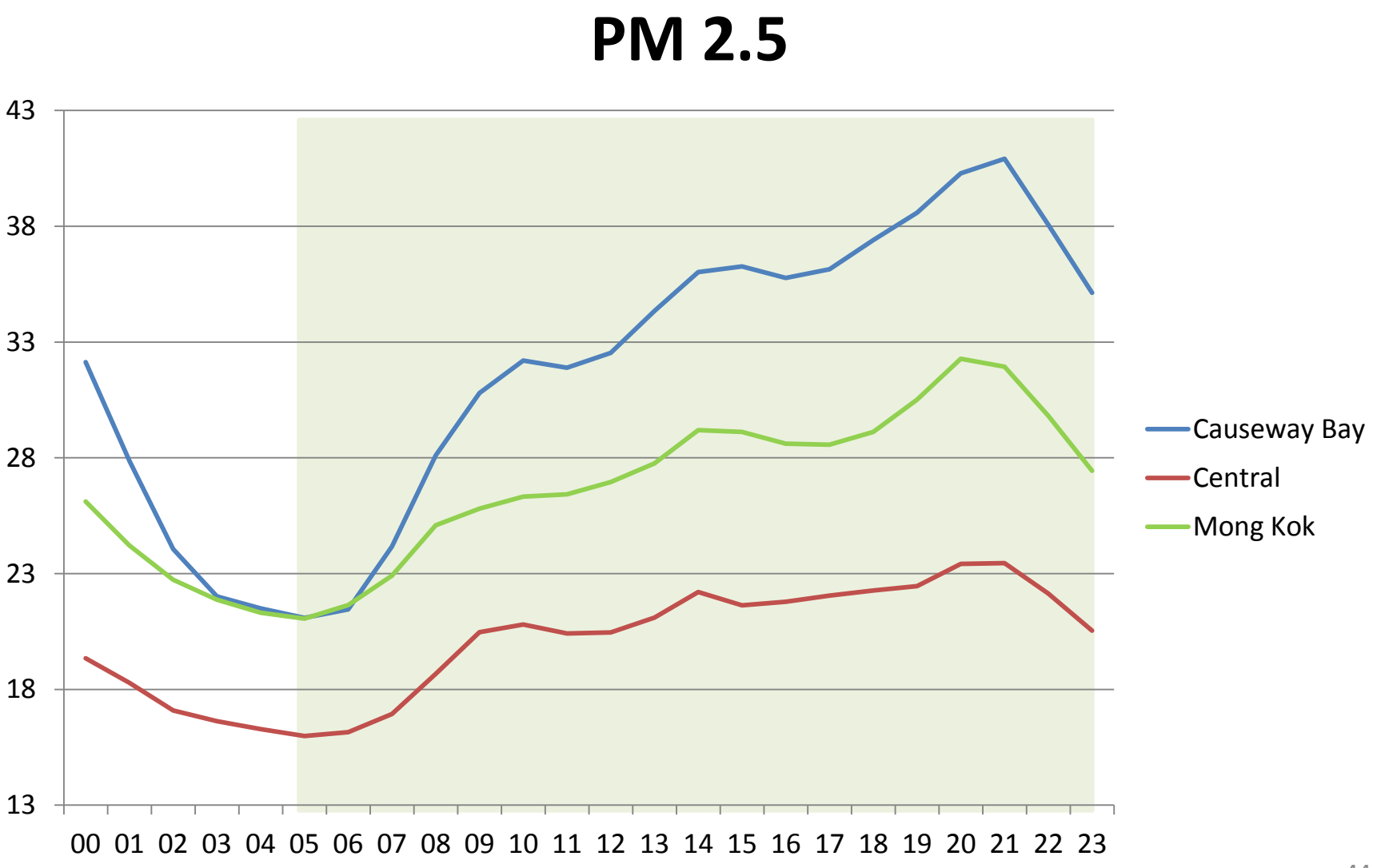


Mortality, all-cause, all ages: SSP (+2.2%) Eastern (+1.3%) Tuen Mun (+2.5%)
Hospital admissions, respiratory diseases, all ages: SSP (+3.4%) Eastern (+2.0%) Tuen Mun (+3.8%)

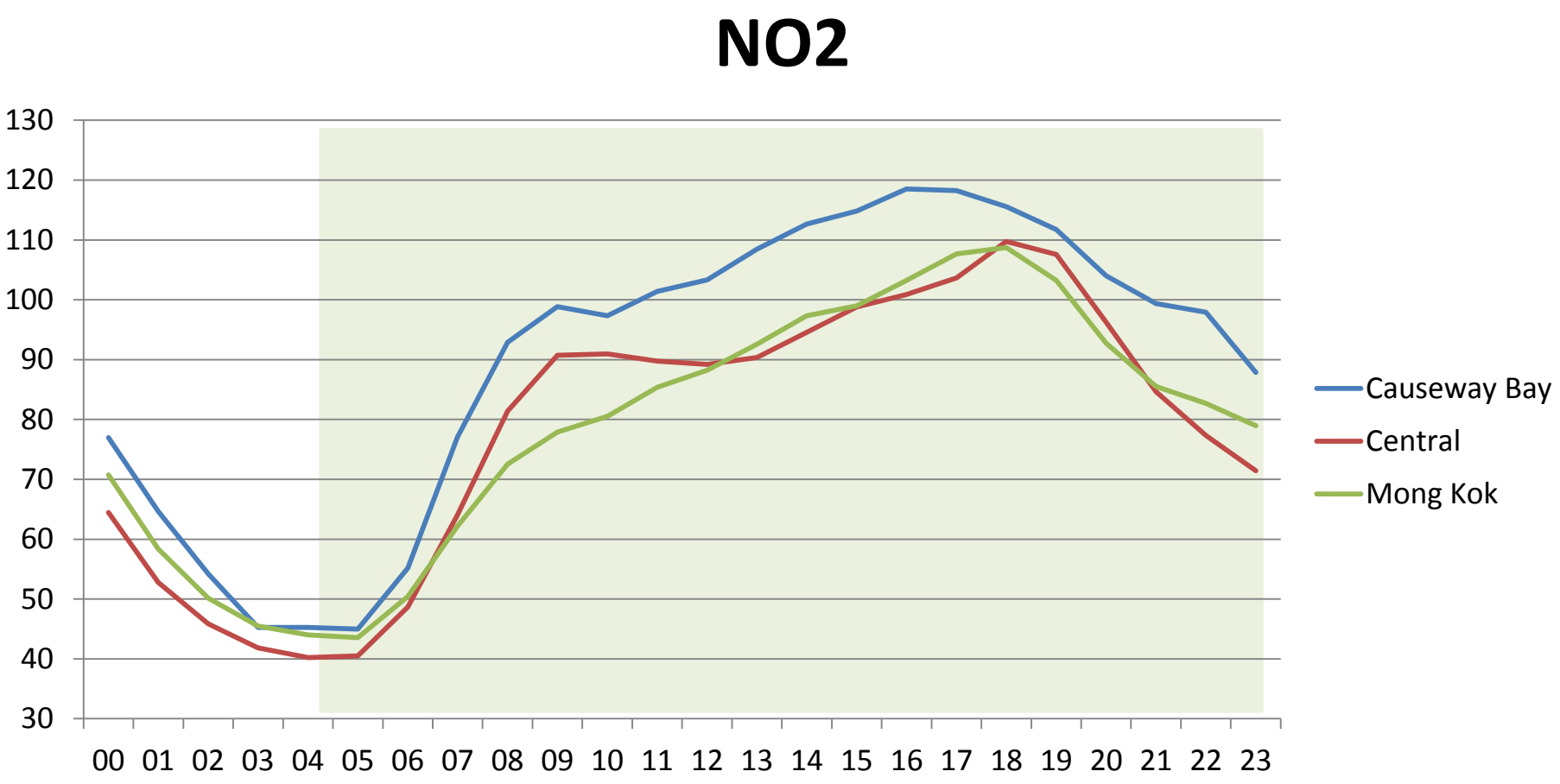
Diurnal Variation – PM 10 (Roadside Stations)



Diurnal Variation – PM 2.5 (Roadside Stations)



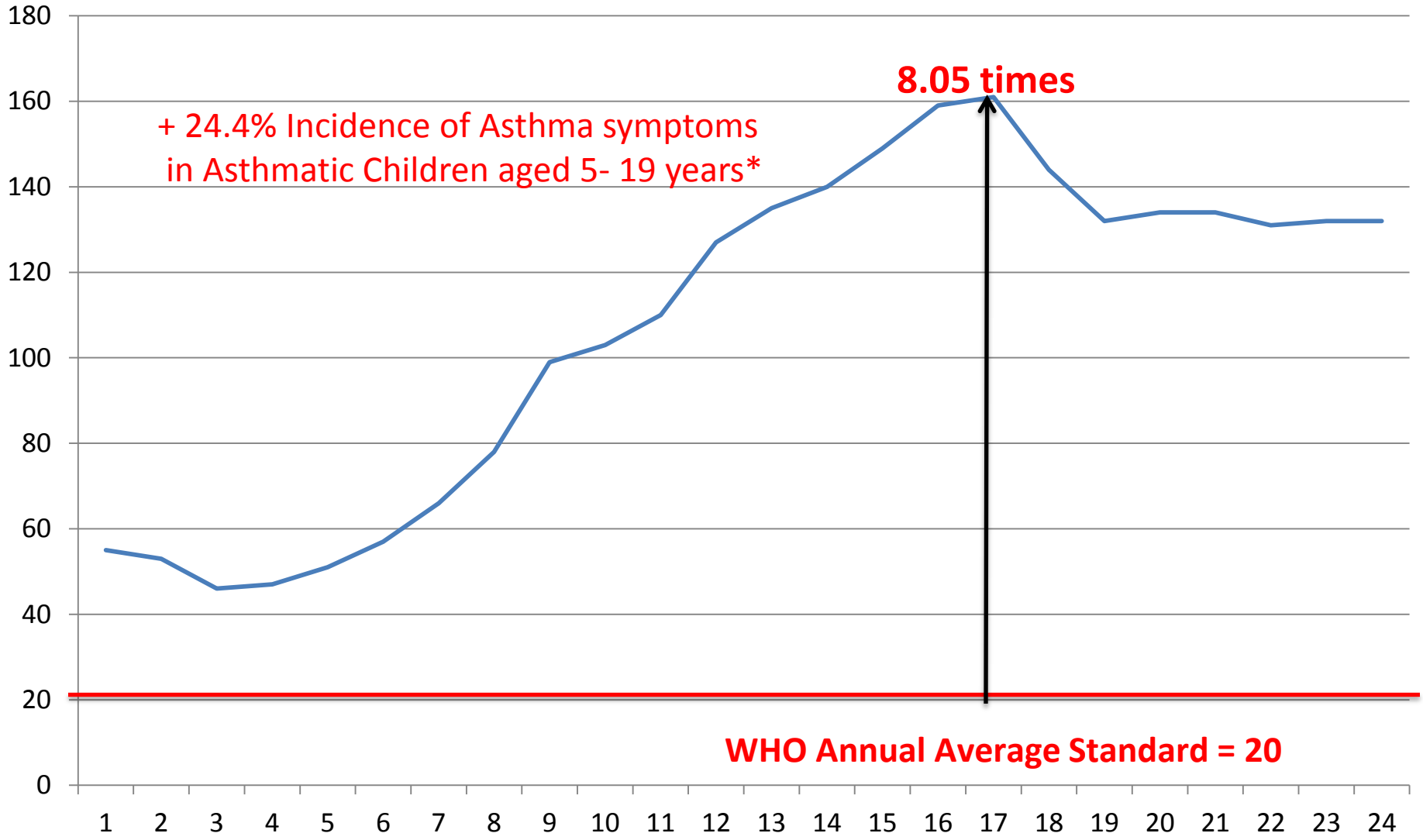
Diurnal Variation – NO2 (Roadside Stations)



CASE STUDIES

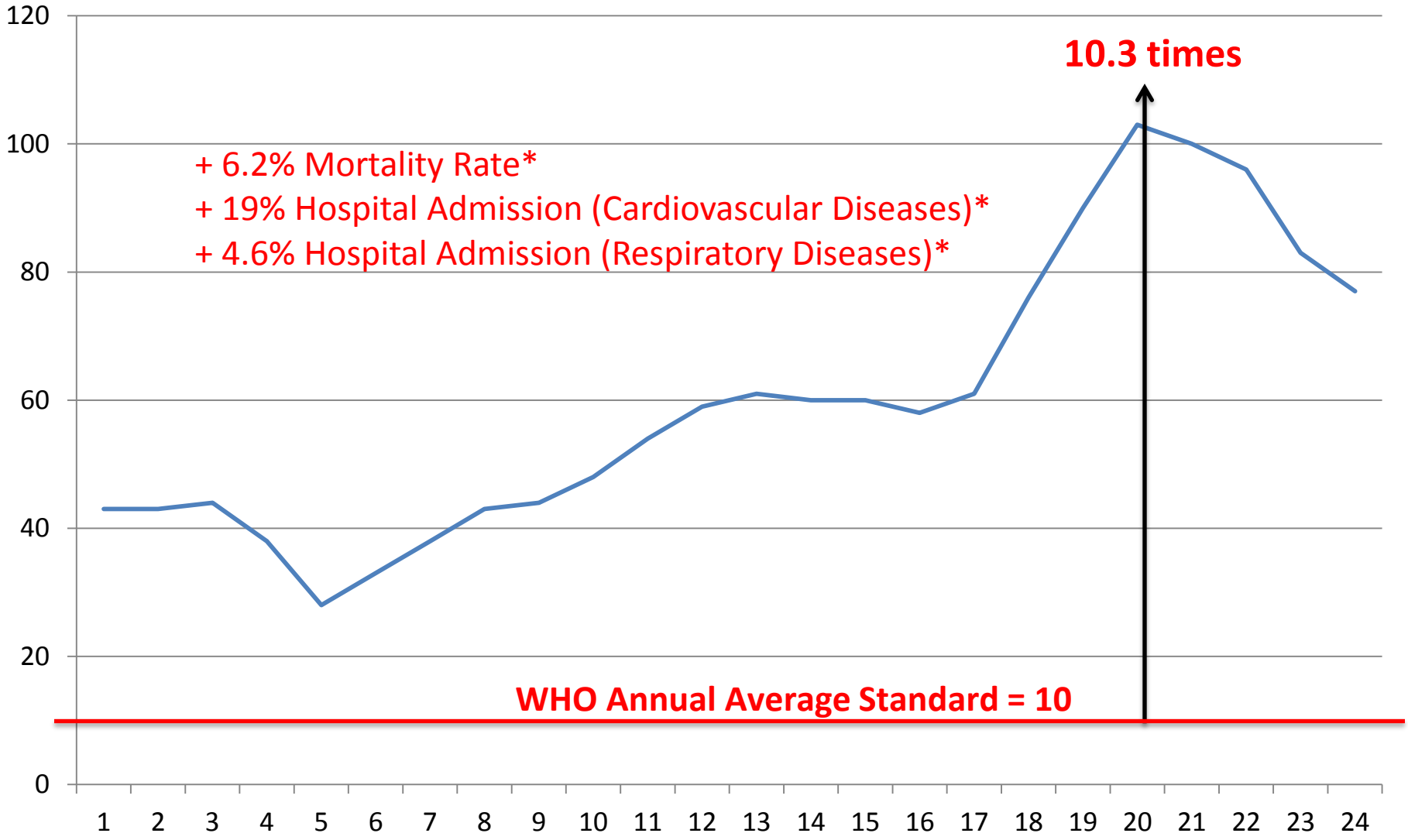
- A day was chosen recorded with the highest level of 3 types of air pollutants throughout a year
  - Causeway Bay Roadside – PM2.5
  - Sham Shui Po General – PM10
  - Mongkok Roadside – NO2

Case 1: Diurnal Variation of PM10 in Sham Shui Po (21/2/2016)



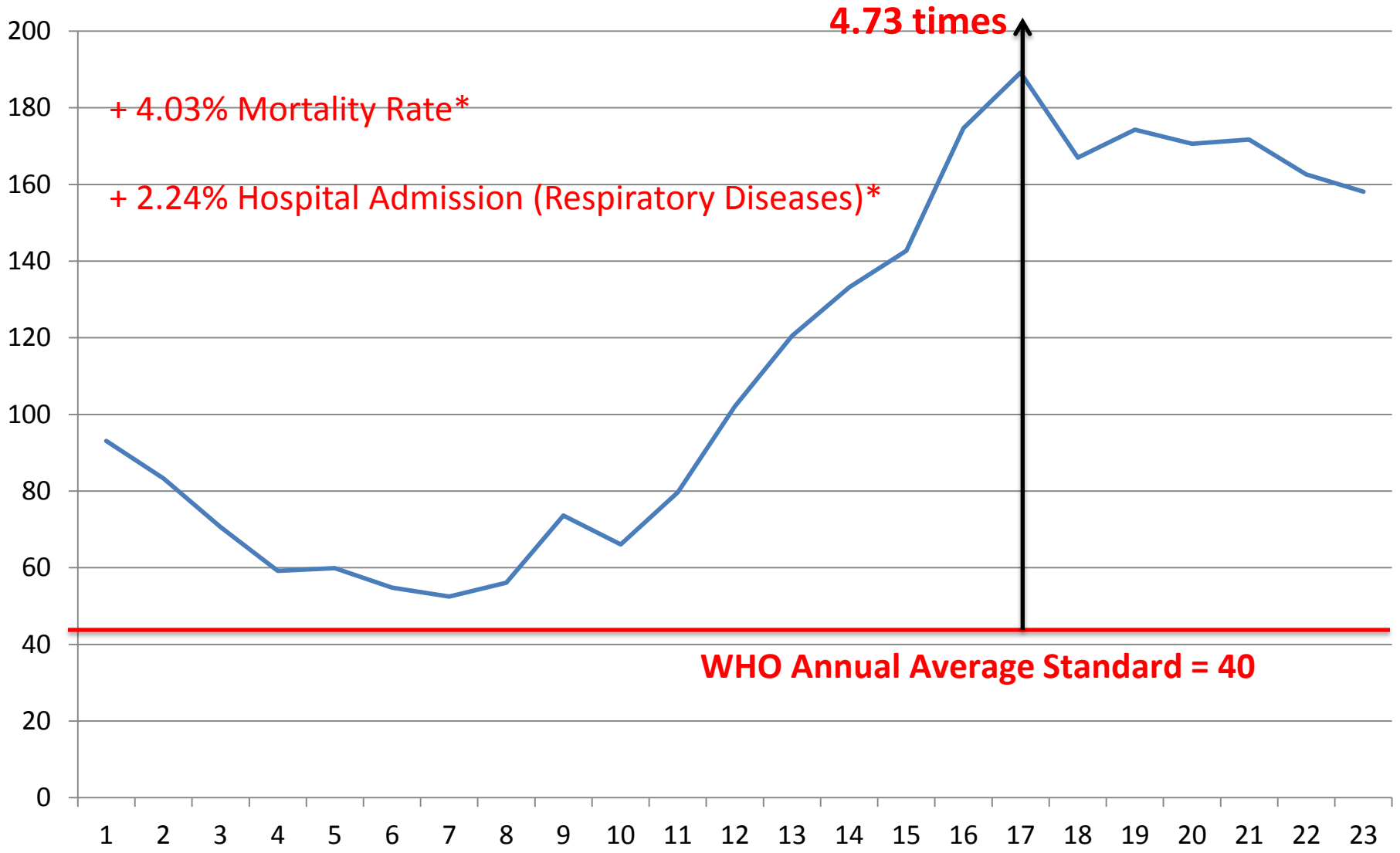
*Pollutant Metric: PM10, daily mean

Case 2: Diurnal Variation of PM2.5 in Causeway Bay (1/1/2016)



*Pollutant Metric: PM2.5, daily mean

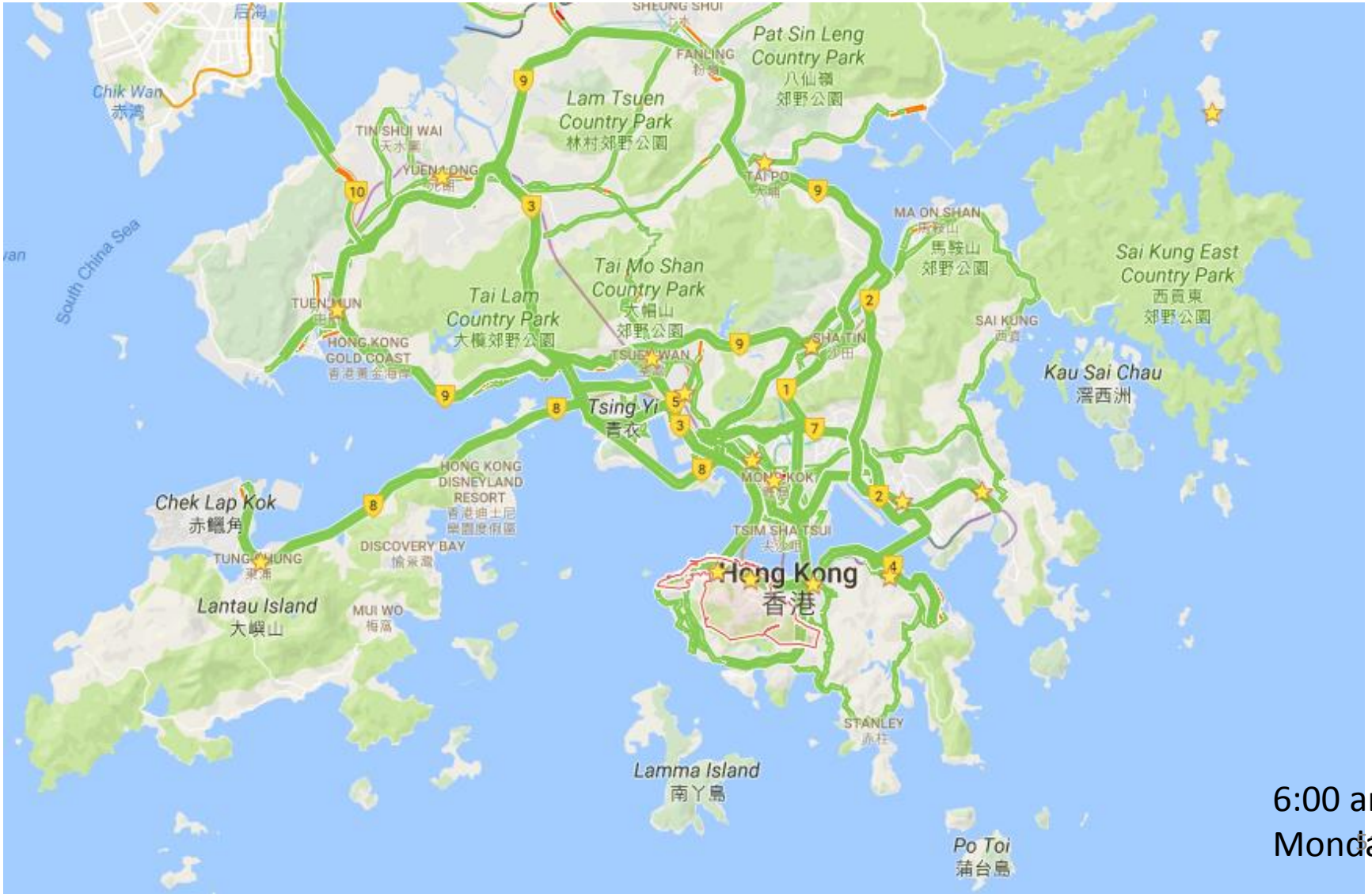
Case 3: Diurnal Variation of NO2 in Mong Kok (4/12/2016)



*Pollutant Metric: NO2, daily maximum 1-hour mean (17:00)

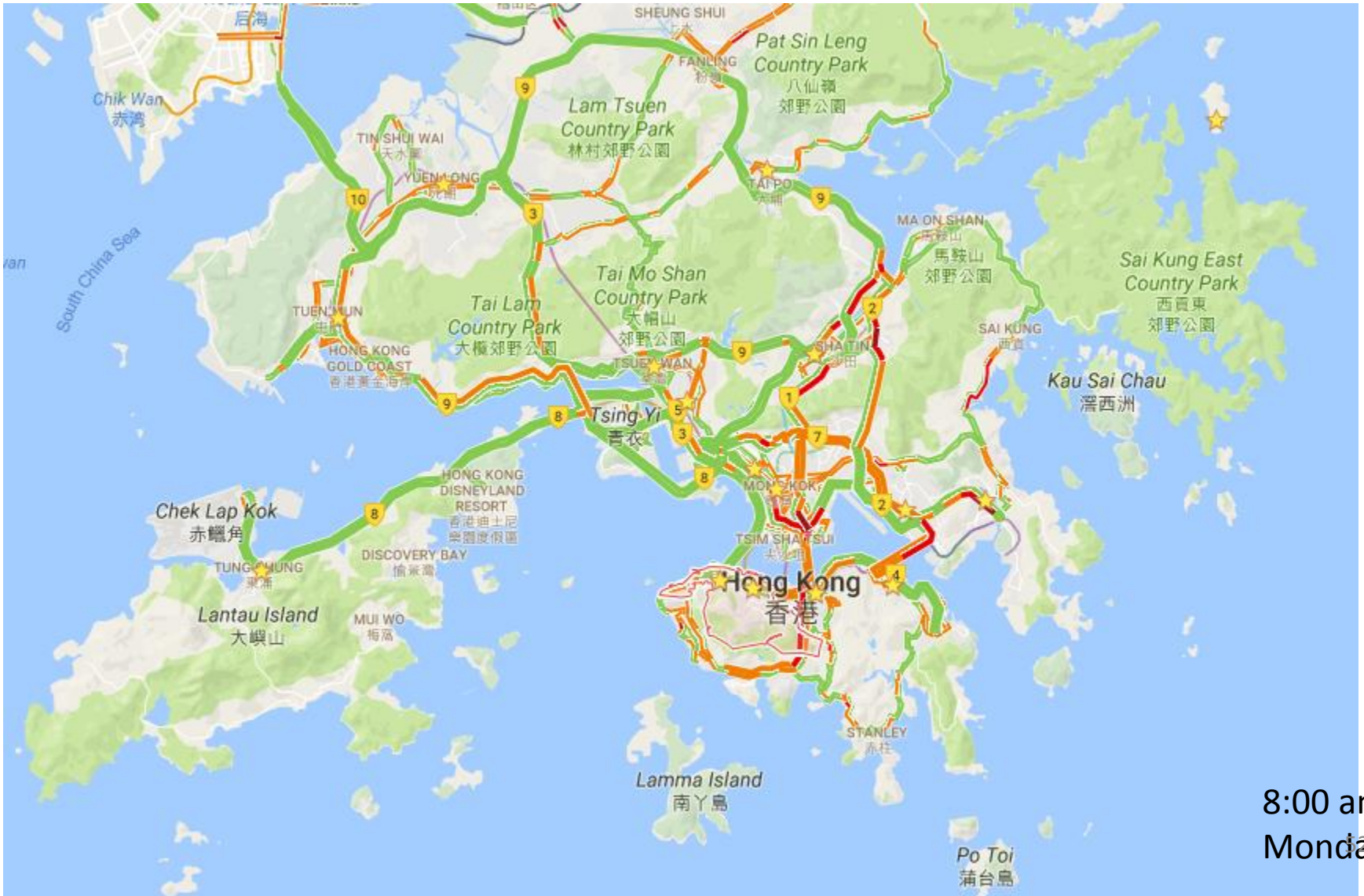
What happened?

Traffic Condition at different times



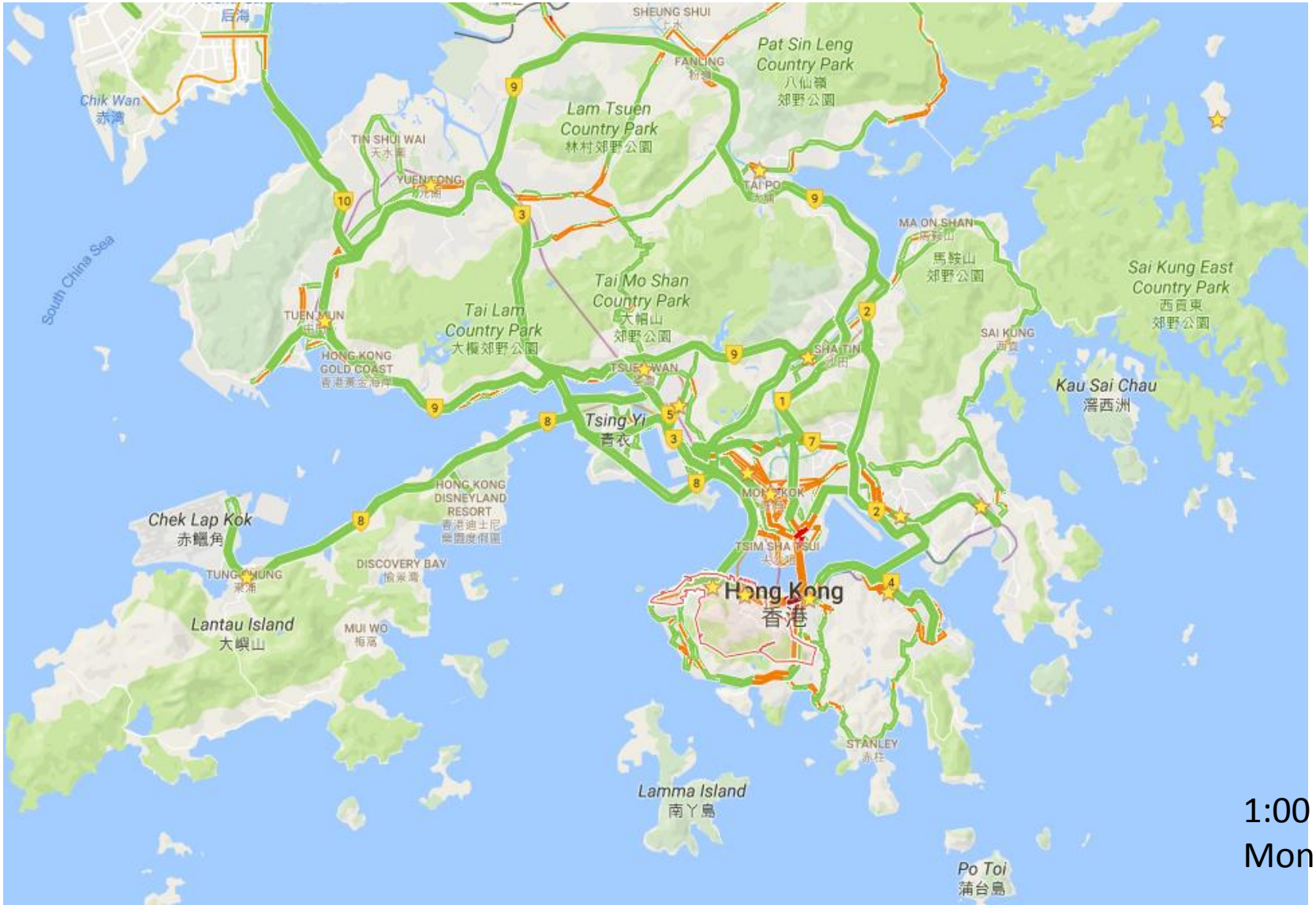
6:00 am, Monday

Traffic Condition at different times



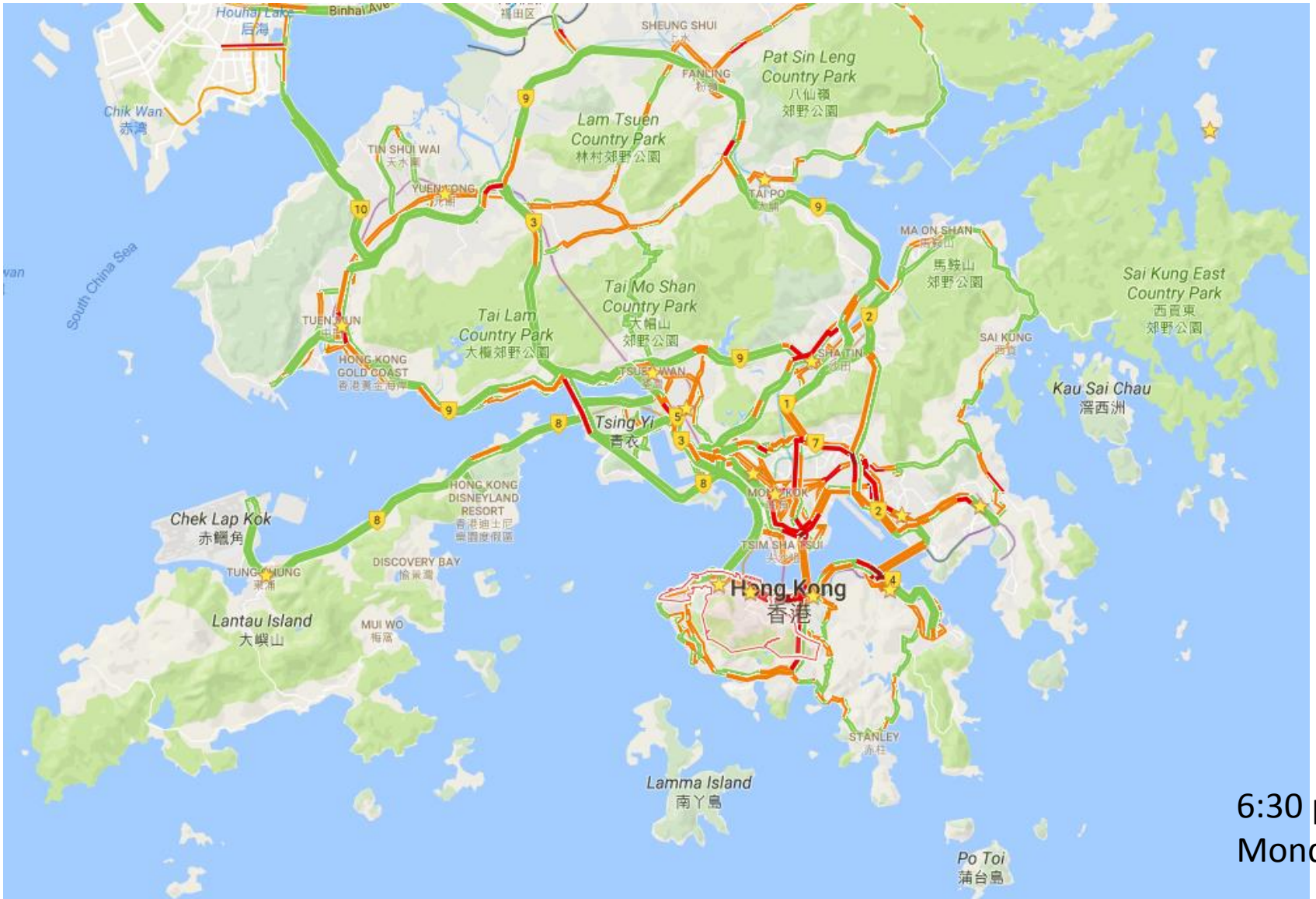
8:00 am, Monday

Traffic Condition at different times



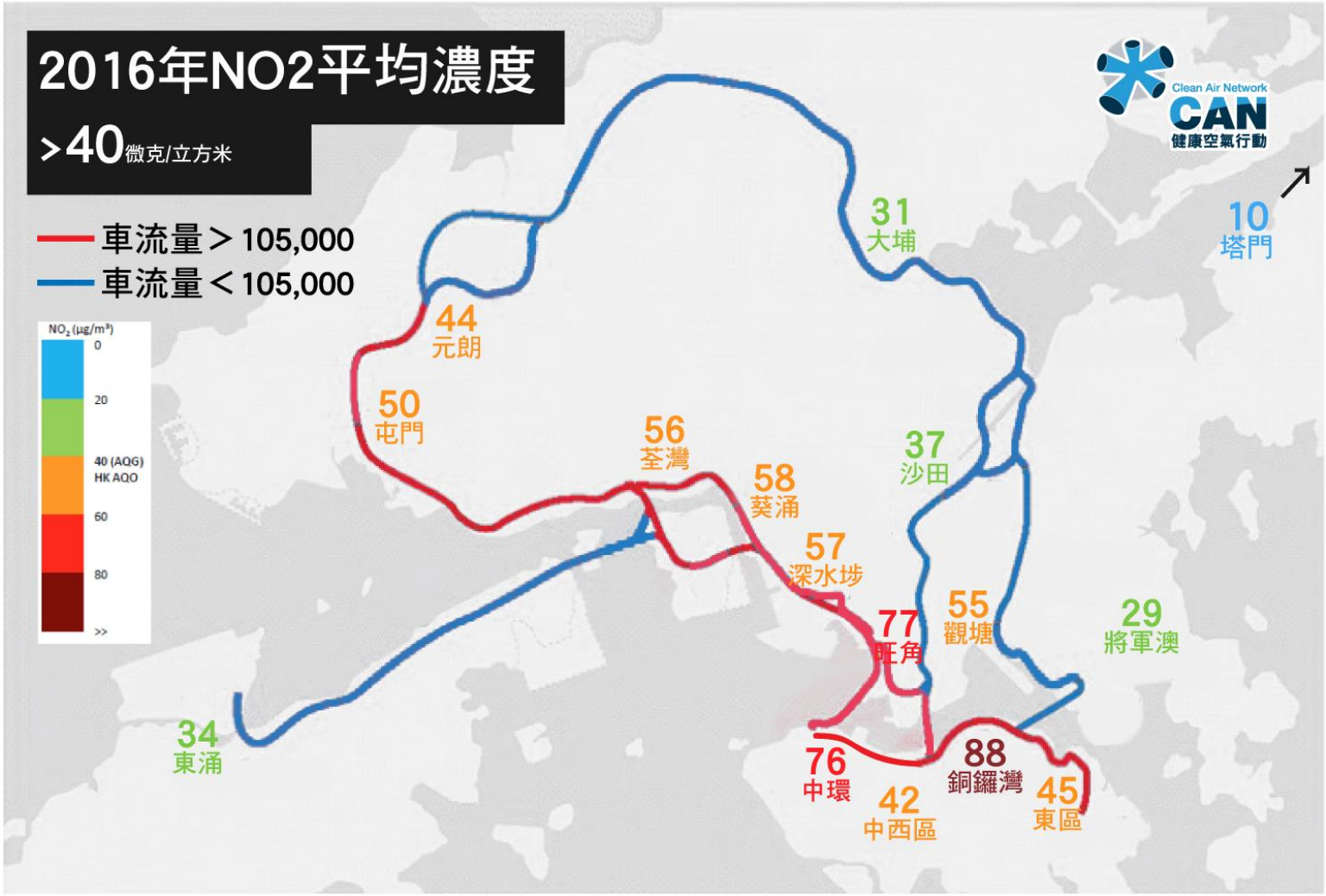
1:00 pm, Monday

Traffic Condition at different times



6:30 pm, Monday

Spatial Distribution of annual average pollution level and annual average daily traffic



Observations:

1. Roadside air pollution level is highly correlated with the traffic volume on hourly basis
2. Closer to peak hours, more congested
3. Busiest period in a typical day: 8.00am and 6.30pm

Observations

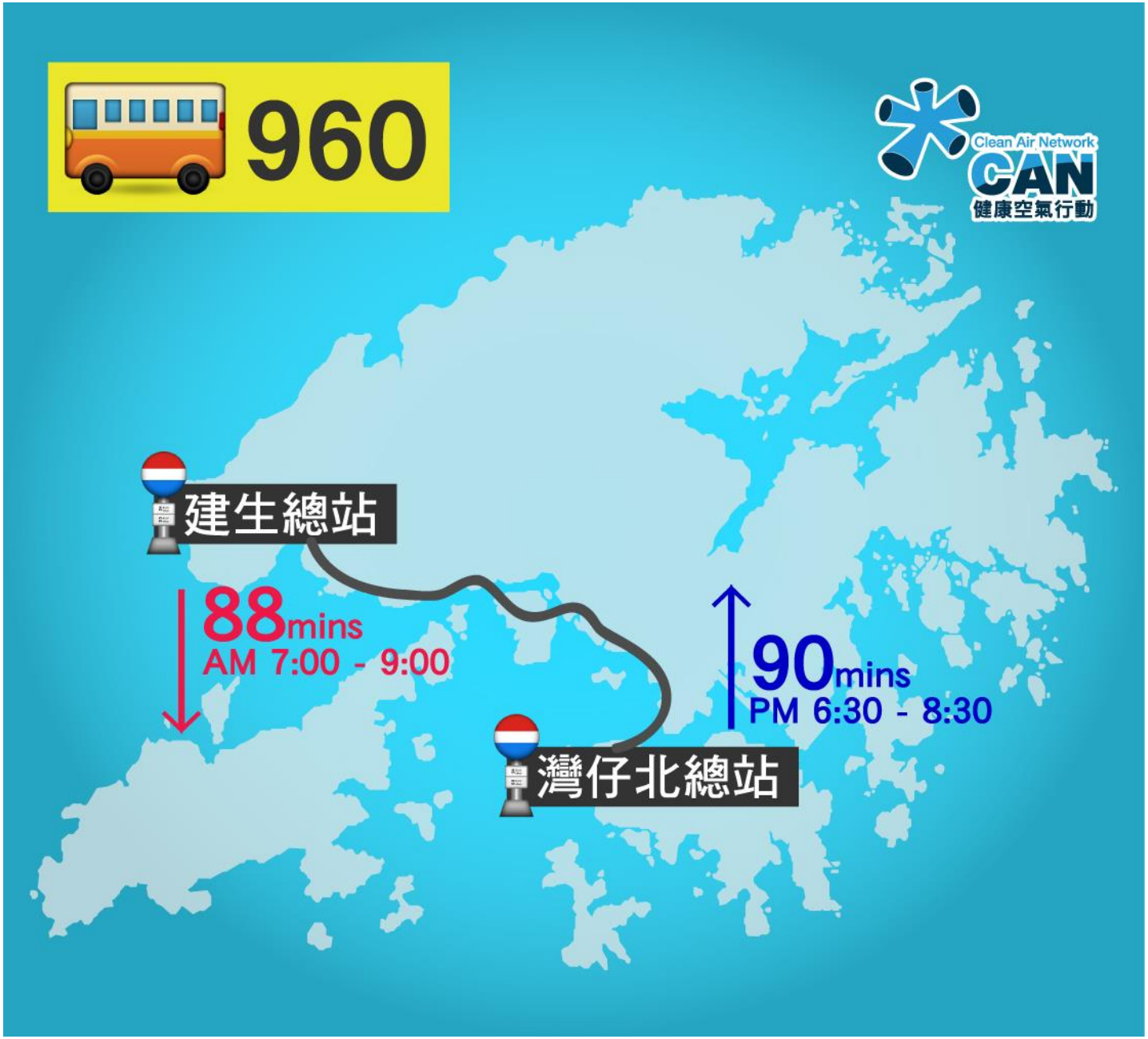
4. Higher pollution in the west and the city centre is correlated to the heavier traffic in the region

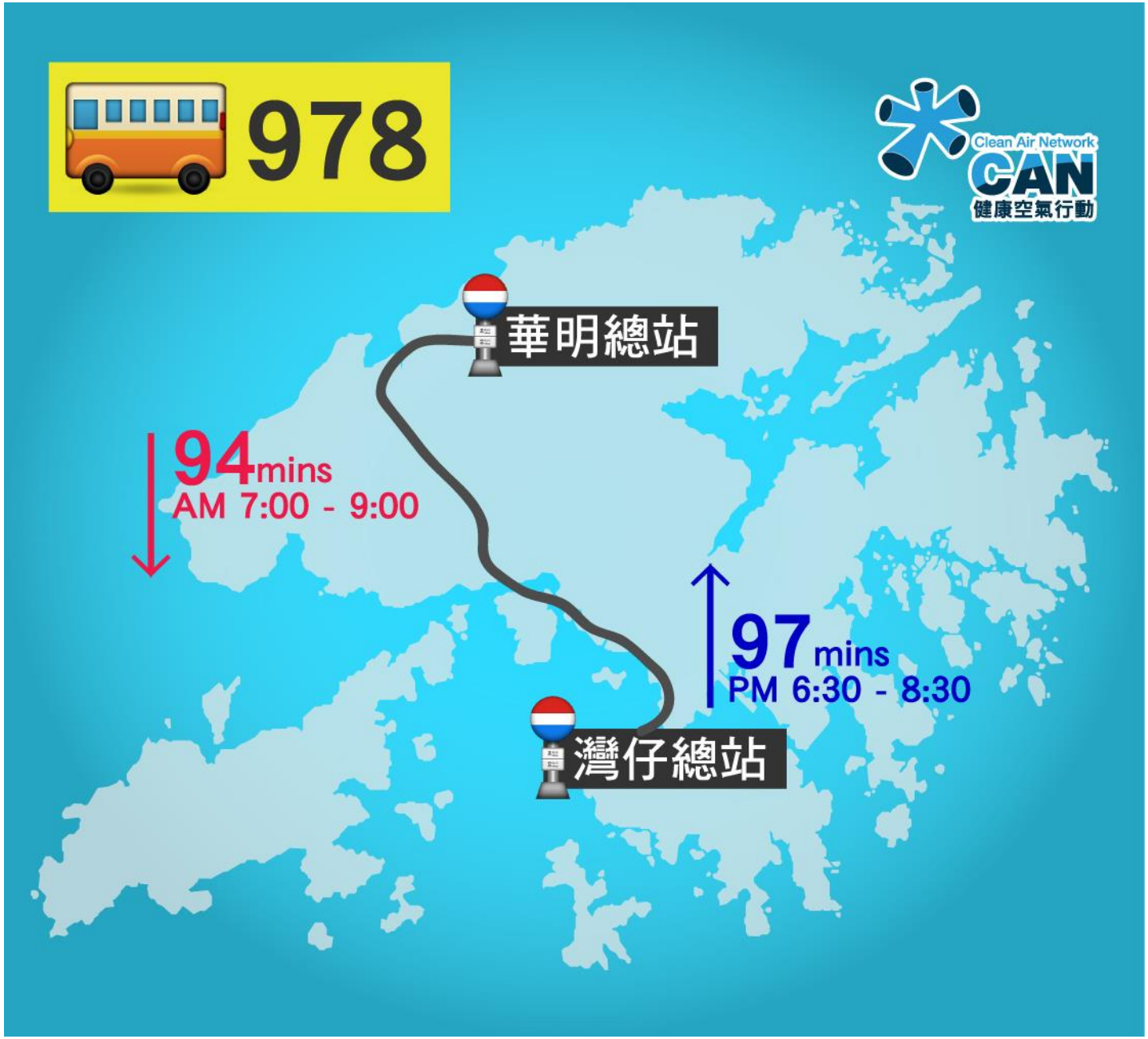
5. Causeway Bay, Central and Mongkok, Tuen Mun, Yuen Long, Kwai Chung, Sham Shui Po are the most polluted districts with higher Annual average daily traffic (AADT) than the eastern regions (i.e. lower AADT)

The following happens everyday…


270A
Clean Air Network
CAN
健康空氣行動
上水總站
95mins
AM 7:00 - 9:00
尖沙咀東
104mins
PM 6:30 - 8:30


678
Clean Air Network
CAN
健康空氣行動
上水總站
101 mins
AM 7:00 - 9:00
111 mins
PM 6:30 - 8:30
銅鑼灣道


960
Clean Air Network
CAN
健康空氣行動
建生總站
88mins
AM 7:00 - 9:00
90mins
PM 6:30 - 8:30
灣仔北總站


978
Clean Air Network
CAN
健康空氣行動
華明總站
94mins
AM 7:00 - 9:00
97mins
PM 6:30 - 8:30
灣仔總站


961P
Clean Air Network
CAN
健康空氣行動
良景邨總站
93mins
AM 7:00 - 9:00
灣仔總站

Multiple impacts on commuters

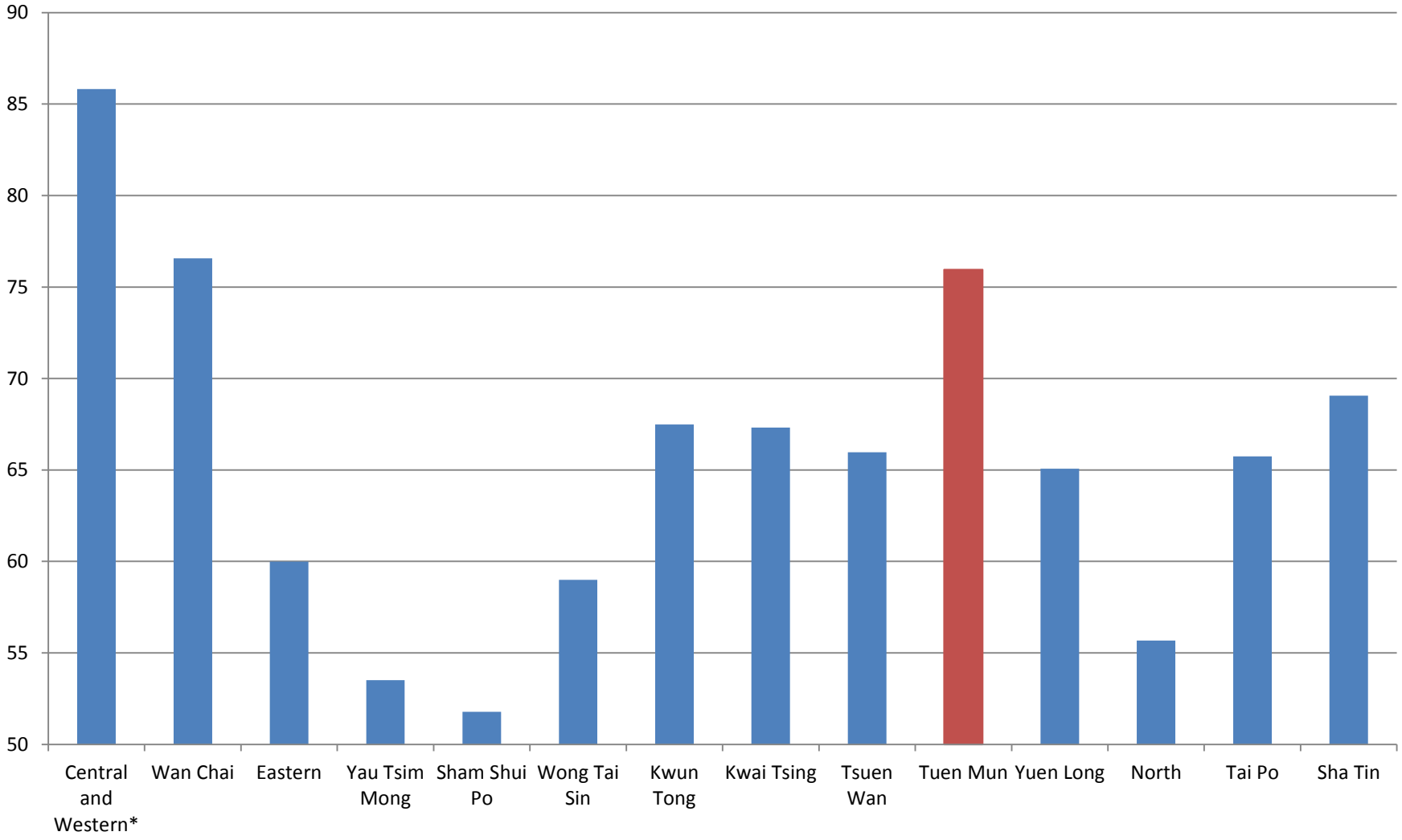
- Long commuting time for residents living in new towns
- Long exposure time to the roadside pollution

What happened in NTW?

Higher proportion of cross-district employment in New Territories West

地區	比率 (跨區工作人口:同區工作人口)
香港島	2.1:1
九龍西	3.3:1
九龍東	3.8:1
新界西	4.3:1
新界東	5.1:1

Percentage of Road Transport Usage for commuting to work (Districts connected with MTR)



*Western Extension of MTR was not opened in 2011

Transport Infrastructure Development in New Territories West
Expected Aggravated Traffic Flow

鐵路項目

至2010年（在現有鐵路網絡上已落實興建的項目）
- 將軍澳南站
- 九龍南線
- 上水至落馬洲支線

至2020年（在2010年的鐵路網絡上新增的項目）
- 沙中線
- 觀塘線支線
- 北環線
- 廣深港高速鐵路香港段
- 西港島線
- 南港島線（東段）

至2030年（在2020年的鐵路網絡上新增的項目）
- 北港島線
- 南港島線（西段）

	青衣西南	大嶼山西北
	經濟及財務	
贊成	• 財務上可行：每TEU的平均增加財務成本*為723港元，財務內部回報率**為12% • 經濟淨現值為128億港元*** • 與1至9號貨櫃碼頭產生協作效應 • 對分段的擴展具彈性	• 財務上可行：每TEU的平均增加財務成本*為576港元，財務內部回報率為18%# • 經濟淨現值為157億港元*** • 較低成本，規劃設計及2020年後的擴展機會更具效益
反對	• 收回及重置成本可增加達49億港元	• 如需另建接駁系統，成本會變得異常高昂 • 產生另一分開運作的貨櫃港#
	環境	
反對	• 廢物管理 — 整治油庫 • 重置具潛在危險的裝置 • 水質 — 可能為淨化海港計劃的排放工作帶來影響	• 生態 — 影響中華白海豚（造成直接生境損失） • 景觀 — 對鄉郊/未發展區域帶來永久的改變，包括對大澳的視覺影

主要道路項目

至2010年（在現有道路網絡上已落實興建的項目）

新界
- 8號幹線（沙田至青衣路段）
- 青山公路擴闊路段工程（荃灣第二區至小欖）

跨界
- 港深西部通道
- 后海灣幹線

至2020年（在2010年的道路網絡上新增的項目）

香港
- 中環灣仔繞道
- 東區走廊改善工程（銅鑼灣至北角）

九龍
- 加士居道天橋擴闊工程
- 中九龍幹線
- T2幹道（啟德至茶果嶺）

新界
- 吐露港公路／粉嶺公路擴闊工程（舊政務司官邸附近道路交匯處至粉嶺）
- 將軍澳至藍田隧道
- 將軍澳跨海連接路
- 西貢公路分隔車道建造工程（清水灣道至西貢市）
- 大嶼山P1公路（東涌至欣澳）
- *新界西北與北大嶼山之間的策略性南北連接路

跨界
- ^港珠澳大橋
- 港珠澳大橋的北大嶼山公路連接路

至2030年（在2020年的道路網絡上新增的項目）

香港
- 第四條海底隧道
- 4號幹線（堅尼地城至香港仔），作為南港島線（西段）的替代方案

新界
- 東部走廊（新界東北至九龍）
- 青衣至大嶼山連接路—連沿岸公路及竹篙灣連接路（扒頭鼓段）

資料來源: 香港2030規劃願景與策略

地區	District	2014年底總存量 Stock at year-end	2015年落成量 Completions
中西區	Central and Western	92 015	438
灣仔	Wan Chai	62 505	1 418
東區	Eastern	127 376	595
南區	Southern	42 039	8
港島	***HONG KONG***	***323 935***	***2 459***
油尖旺	Yau Tsim Mong	112 535	114
深水埗	Sham Shui Po	74 095	592
九龍城	Kowloon City	101 227	1 178
黃大仙	Wong Tai Sin	19 123	-
觀塘	Kwun Tong	47 225	-
九龍	***KOWLOON***	***354 205***	***1 884***
葵青	Kwai Tsing	35 503	-
荃灣	Tsuen Wan	77 384	-
屯門	Tuen Mun	57 477	7
元朗	Yuen Long	72 949	1 381
北區	North	27 597	-
大埔	Tai Po	31 066	1 370
沙田	Sha Tin	77 668	2 085
西貢	Sai Kung	55 905	596
離島	Islands	22 741	1 498
新界	***NEW TERRITORIES***	***458 290***	***6 937***
全港	***OVERALL***	***1 136 430***	***11 280***

New residential development is clustered in Yuen Long, Tung Chung, Sham Shui Po and Kowloon City

資料來源:香港物業報告2016

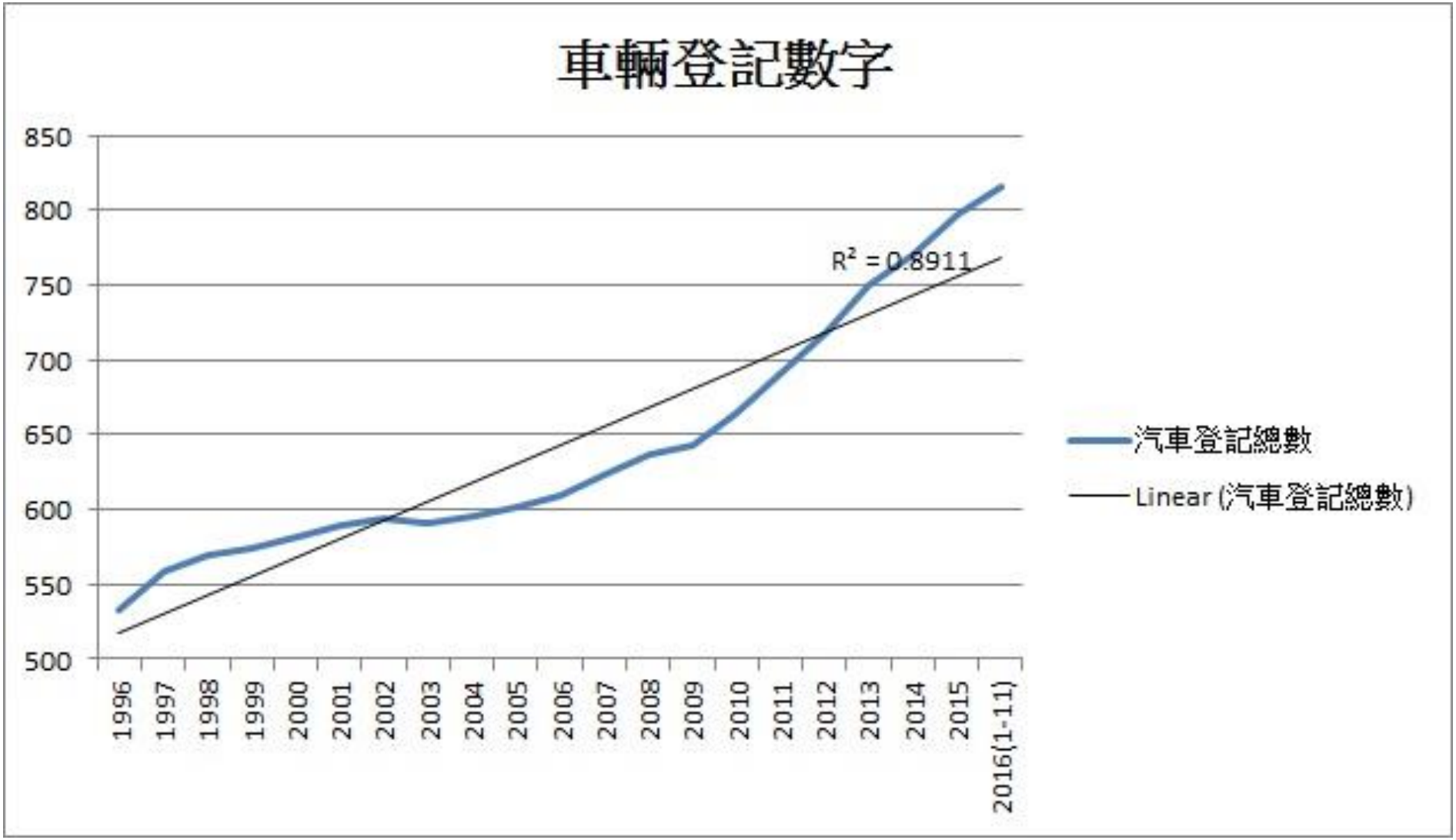
3. TRAFFIC, AIR, HEALTH

- Vehicle growth
- Air pollution emission control measures
- Health impact and other social costs

Almost Double of car registration over the last 20 years

- 1995: 530,000
- 2016: 820,000
- Increase 1.5 times

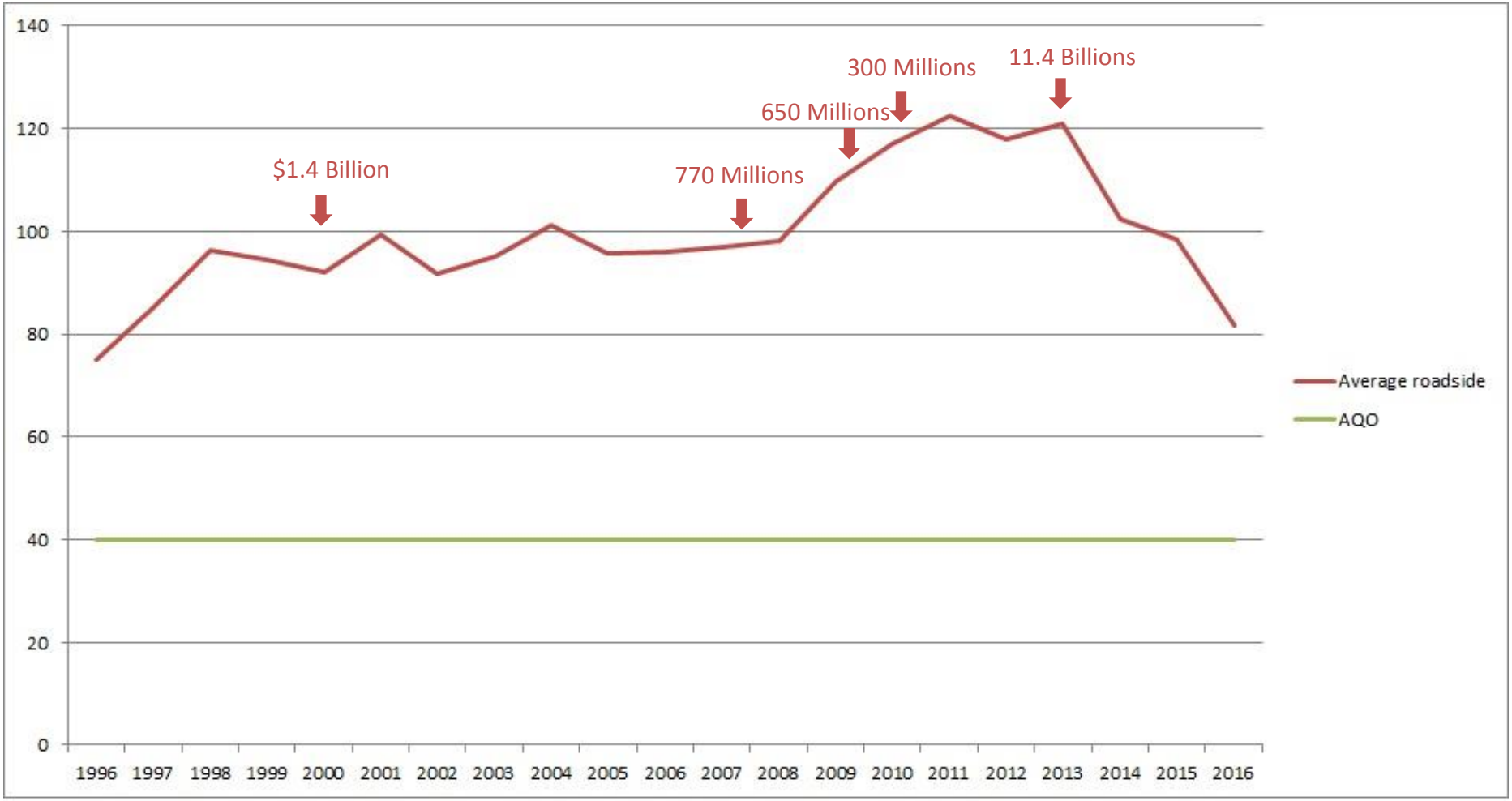
Almost Double of car registration in 20 years



Roadside emission measures (2012-now)

Measures	Contents	Target reached?
Wider use of electric vehicles	6,860 total EVs / 523,960 p.vehicles =1.3%, whereas target =20%	6.5%
Trial of single-deck electric buses	5 electric buses / 36 total buses, and recalled 3rd times in 9 months	13.9%
Retrofit Euro II and III franchised buses with SCRs	360(installed) / 1,040 (uninstalled) (2015 figures, data from 2016 Budget)	25.7%
Phasing out pre-Euro IV diesel commercial vehicles	31,127 (applied payment) / 32,910 (not applied payment)	48%
Low Emission Zones	Low Emission Streets Low Emission Buses 2,348 / 2,453 Total buses in LEZ	Covered area <90% 96%
Air Pollution Control (Non-road Mobile Machinery) (Emission) Regulation	Strengthened emission standard to EU stage IIIA level	100%
Replacement of catalytic converters and oxygen sensors on LPG taxis and light buses	17,000 / 21,000 taxis and light buses participated	80%
Pilot Green Transport Fund	$83M, 92 trials out of $300M fund (since 2011)	27.7% fund used

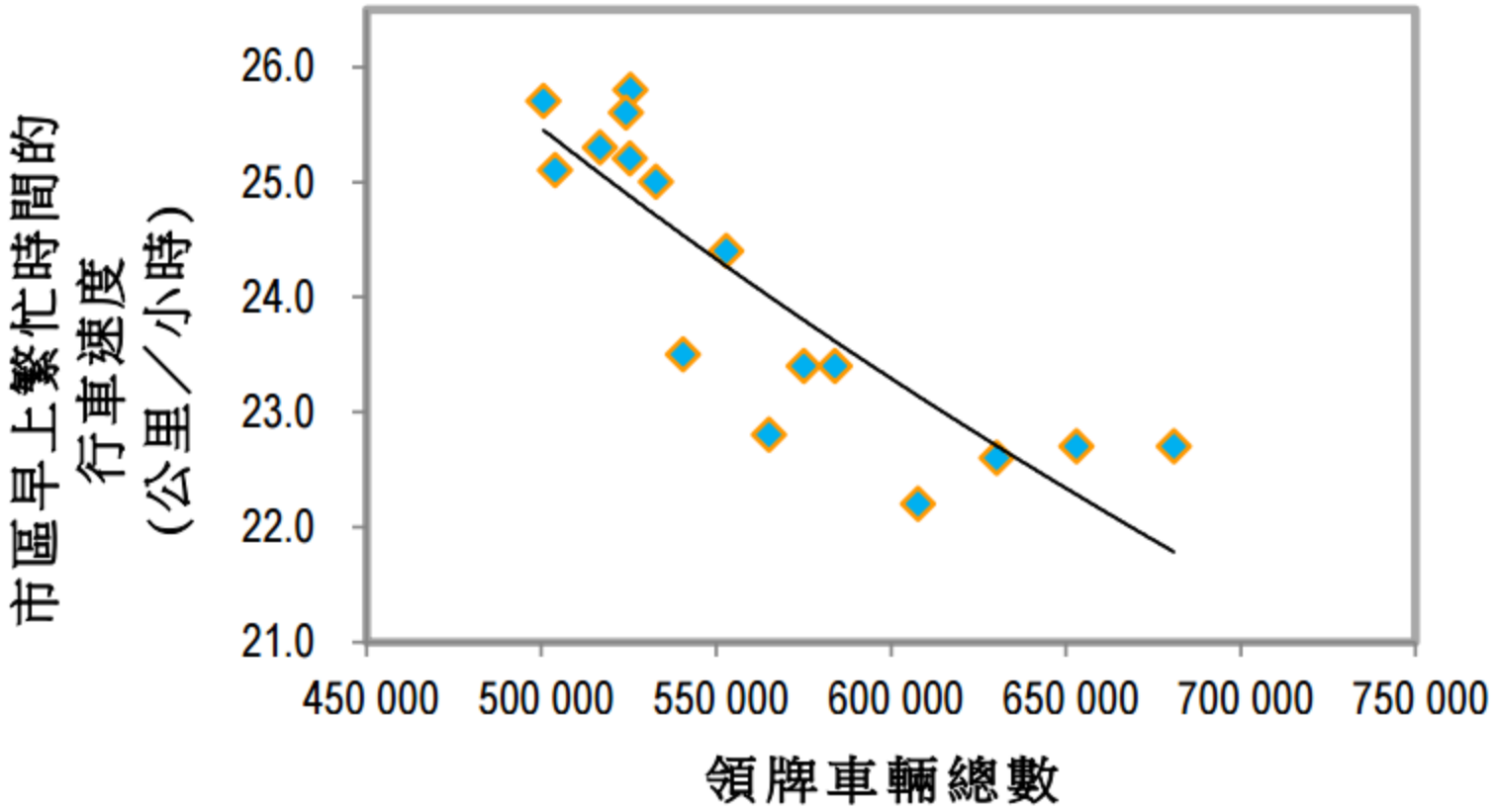
Limitation of emission control measures - Average concentration of roadside emissions did not improve



Total Public Expenditure on Emission Control Measures: $14.5 Billions

Travel time is in constant fall as the registered car continues to grow

圖2D：歷來車輛數目與市區行車速度之間的關係



Cost of Air Pollution in 2016

No. of Premature Death:
1,686

Direct Economic Loss:
HKD 21.6 Billions

No. Additional Doctor Visits:
2.65 million

Source: Hedley Environmental Index of HKU

Insights

- There are too many vehicles
- Traffic, roadside air quality, health are closely correlated
- Traffic is impediment to our living quality

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