

# Air Quality Modelling Using ADMS-Urban for Kuala Lumpur Urban Environment

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# Presentation outline

- **Introduction:**

- Kuala Lumpur
- Urban Atmosphere
- Air Quality Models
- Air Dispersion Modelling System (ADMS-Urban)

- **Objectives**

- **Methodology**

- Model Set Up
- Model Verification

- **Results & Discussion**

- Model Application  
(Air Quality Maps)

- **Summary**





# Kuala Lumpur

## Introduction

### Dataran Merdeka

1970's



### Chow Kit Road

1970's



2017's

### Jalan Sultan Ismail

1970's



2017's

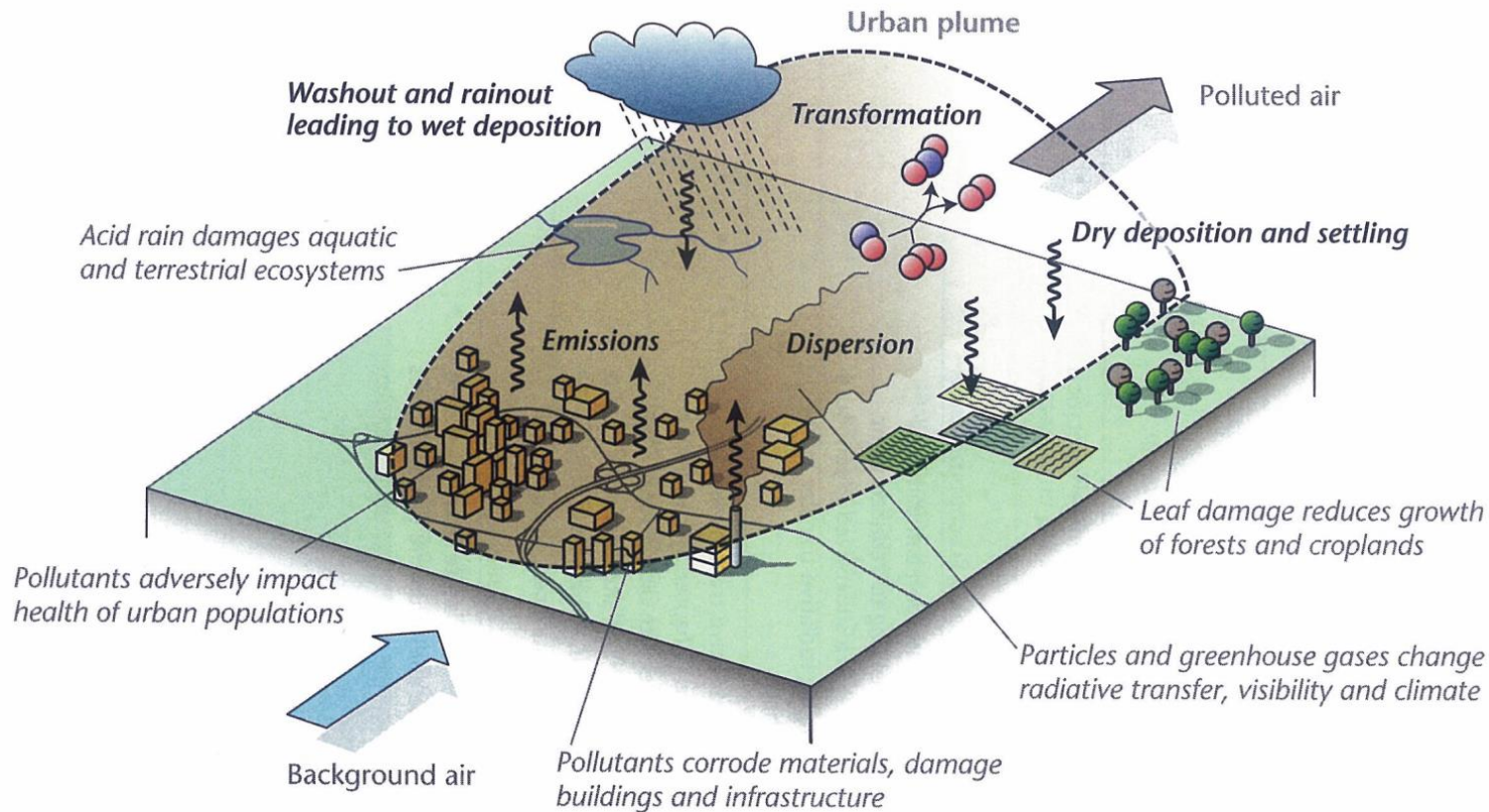
Source: <https://says.com/my>



2017's



# Urban Atmosphere

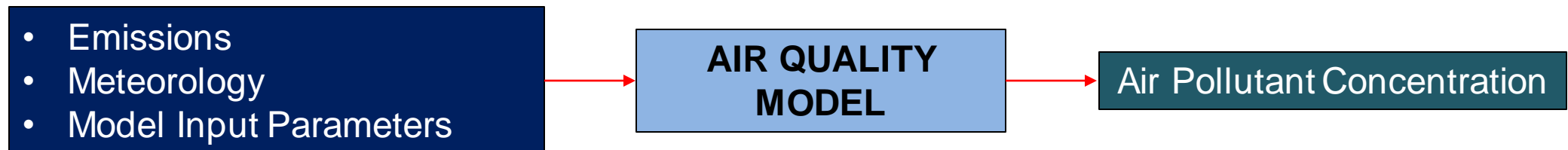


**Figure** : The 'life cycle' of air pollutants in the urban plume, with relevant processes regulating air pollutant concentrations in black and impacts of pollutants in grey italics.

- Proper understanding & management of air pollution in urban environment requires **complete** understanding of the 'life cycle' of air pollutant at the scale of interest.
- Air pollutants consist of **primary** and **secondary pollutants**.
- Disentangling the pathway from primary sources to secondary pollutants is a **challenge** that requires **numerical model** that **incorporate** the appropriate meteorological and chemical processes in the urban atmosphere.

# Air Quality Models

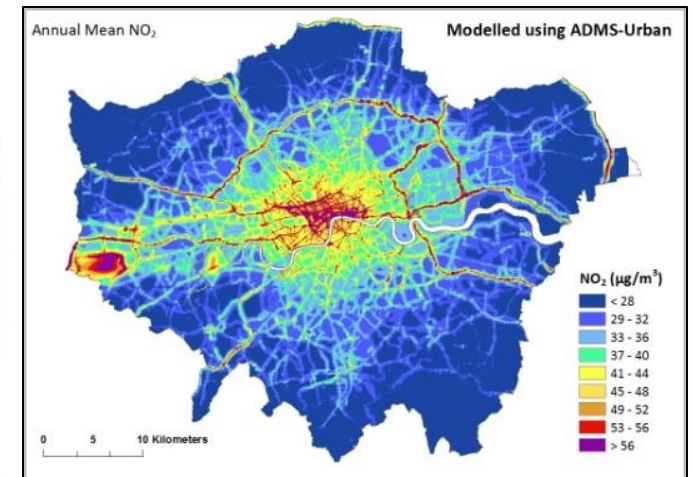
- Air Quality Models are **mathematical formulations** that include parameters that affect pollutant concentrations
- Air pollution modeling is a **numerical tool** used to describe the causal relationship between **emissions, meteorology**, atmospheric concentrations, deposition, and other factors.
- System approach to air quality model



# ADMS-Urban

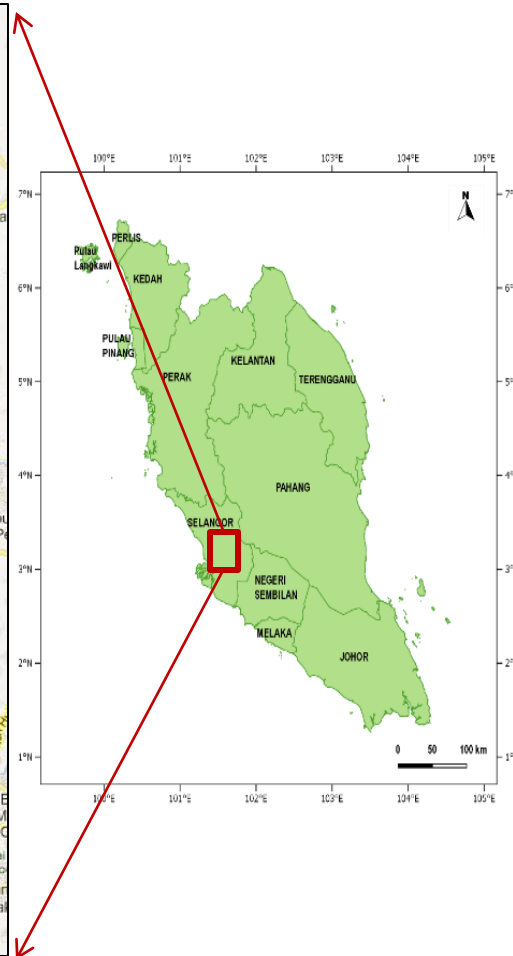
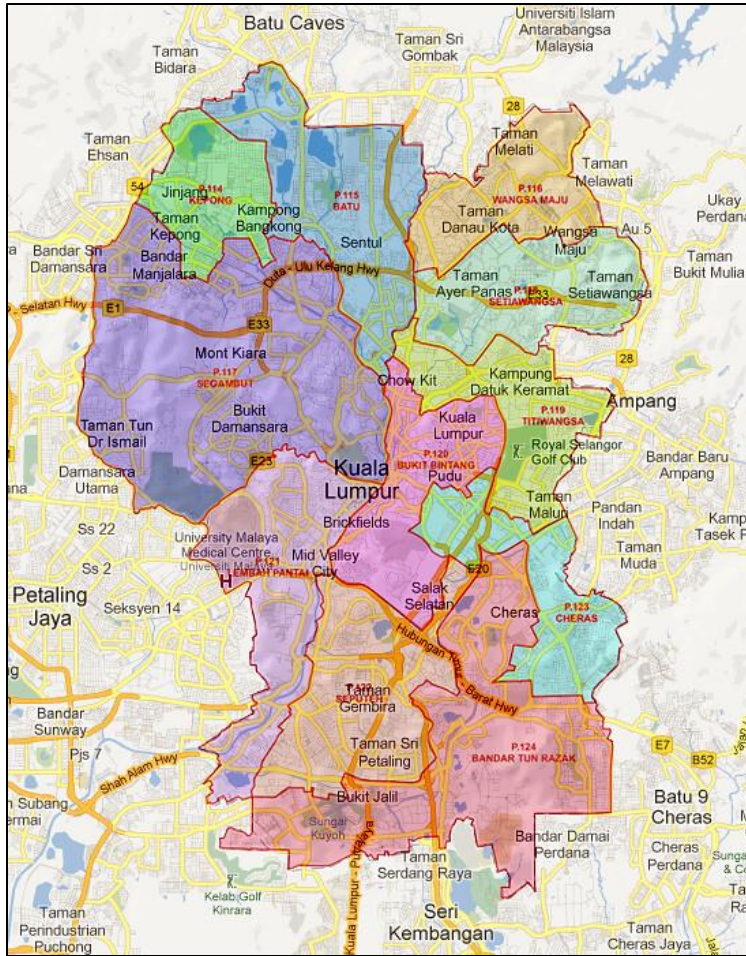
- ability to describe in detail what happens on a range of scales: the **street** scale to the **city-wide** scale.
- **relevant emission sources**: traffic, industrial, commercial, domestic and other less well-defined sources.
- modern approach : parameters are **Monin-Obukhov Length,  $L_{MO}$**  & **boundary layer height,  $h$**
- Simpler terms:  $L_{MO} = \frac{-u_*^3}{B}$

where,  $u^*$  is the friction velocity at the Earth's surface  
 $B$  is the 'buoyancy'





# Objectives

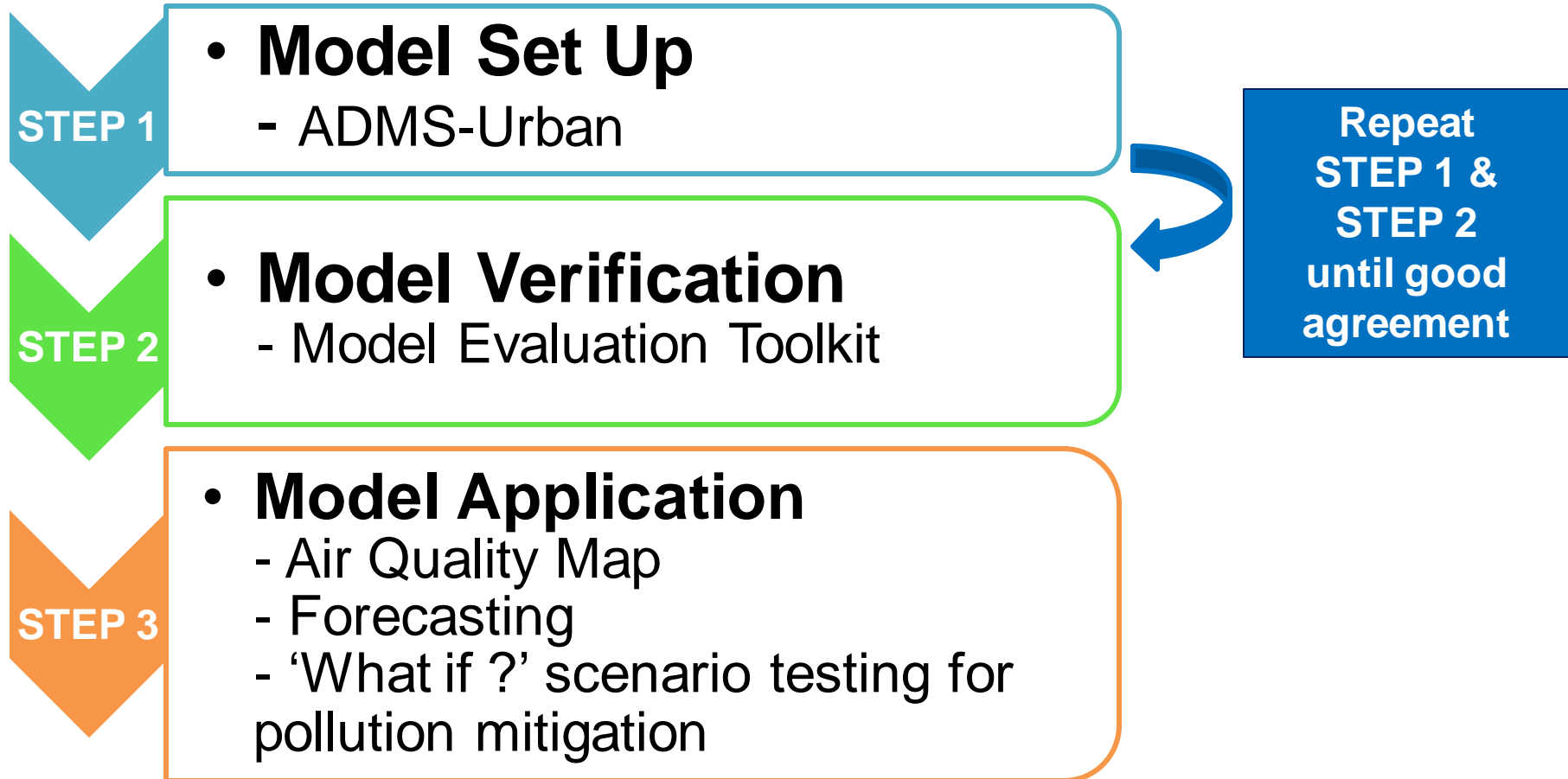


to model the level of  
air quality by using  
ADMS-Urban in  
Kuala Lumpur



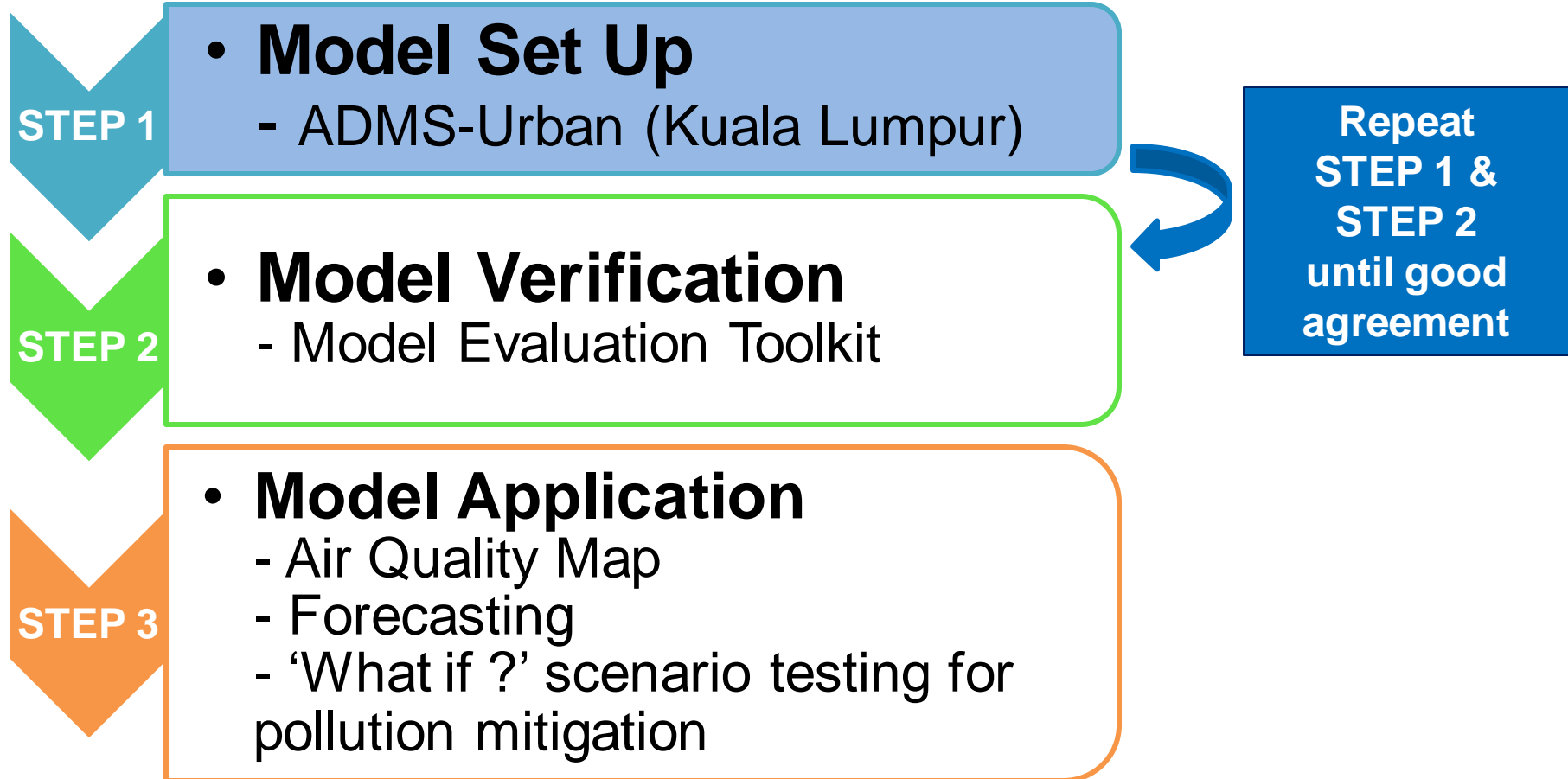
to assess local  
emission from  
different emission  
sources for  
modelling air quality  
in Kuala Lumpur

# Methodology



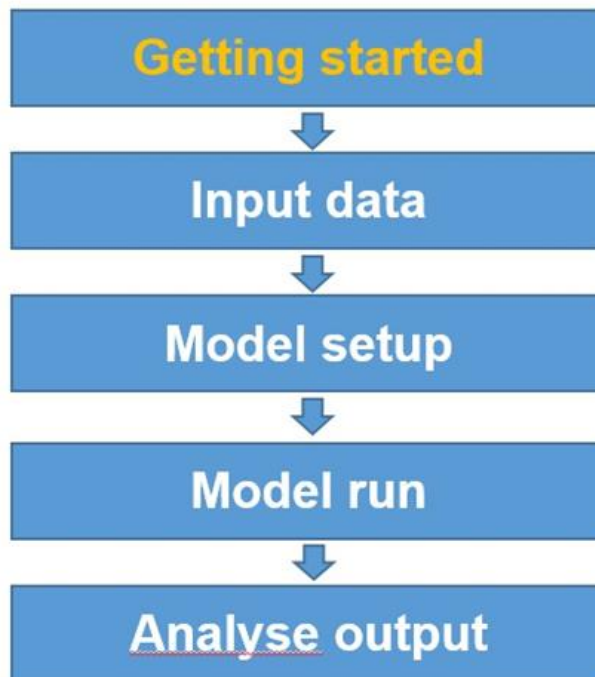


# Methodology

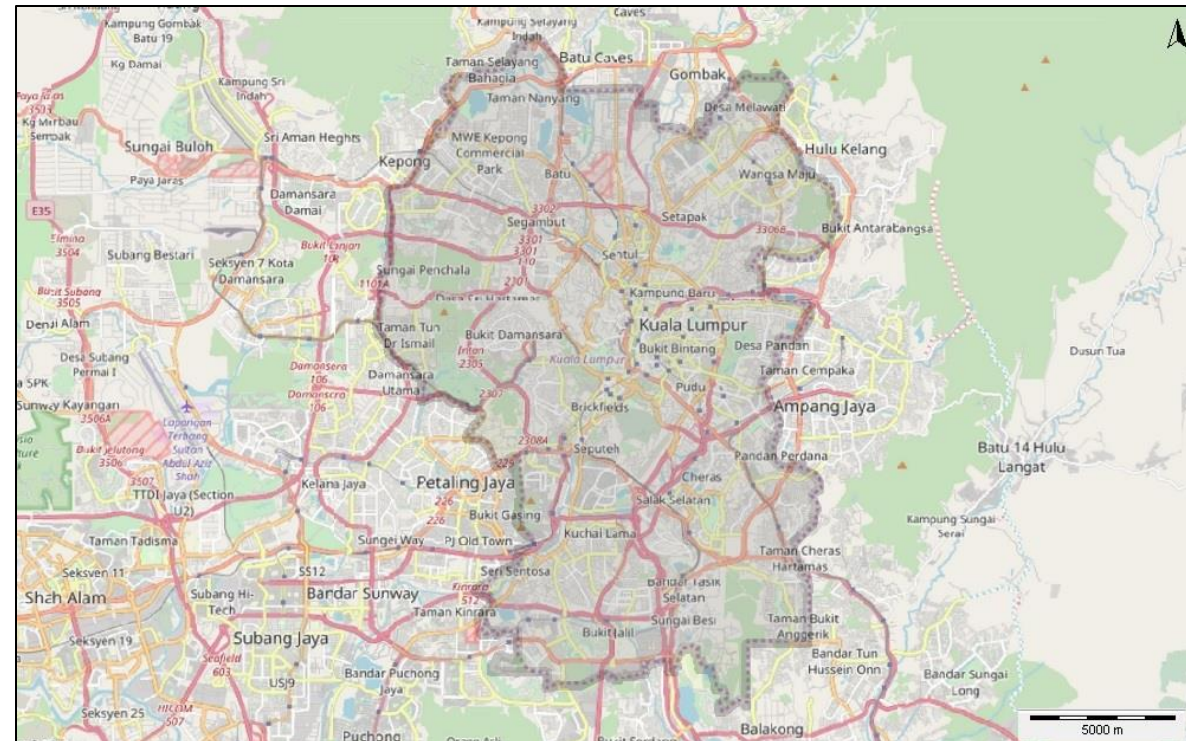


# Model Set Up

## ADMS-Urban

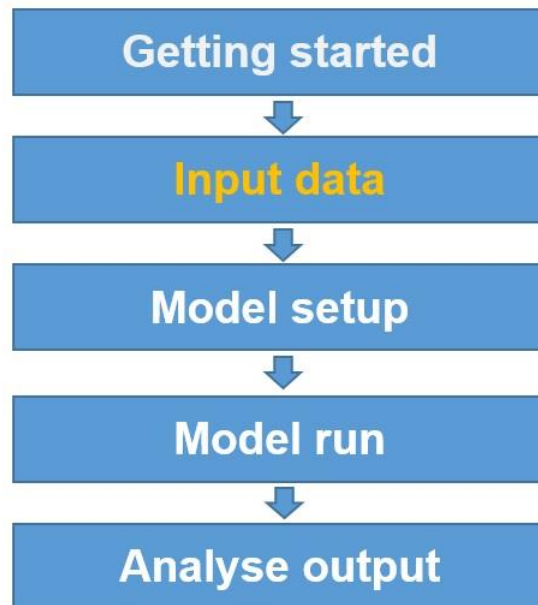


- Domain : **Kuala Lumpur**
- Year : **2014**
- ADMS-Urban Model : **Version 4.1.1**
- Air pollutants : **NO<sub>x</sub>, NO<sub>2</sub>, PM<sub>10</sub>, O<sub>3</sub> & SO<sub>2</sub>**



# Preparation on Input Data

## ADMS-Urban



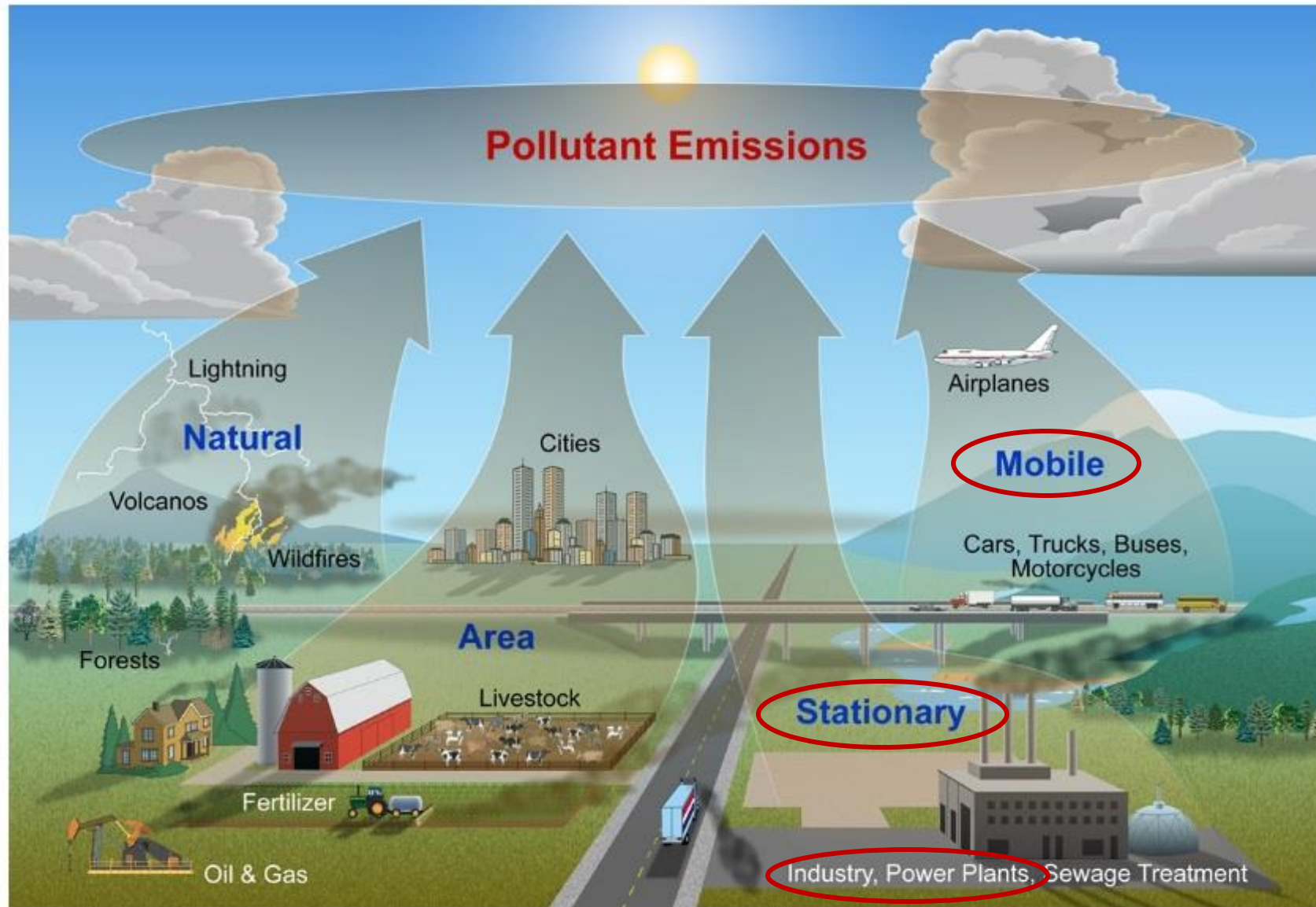
The screenshot shows the 'Setup' window of the ADMS-Urban software. The window has a menu bar with 'File', 'Run!', 'Results', 'Utilities', 'Emissions inventory', and 'Help'. Below the menu bar is a tabbed interface with tabs for 'Setup', 'Source', 'Meteorology', 'Background', 'Grids', and 'Output'. The 'Setup' tab is active. The window contains several input fields and checkboxes:

- Name of site:** An empty text field.
- Name of project:** An empty text field.
- Coordinate system:** A dropdown menu showing 'Unspecified regular Cartesian'.
- Model options:** A group box containing several checkboxes:
  - ☐ Dry deposition
  - ☐ Wet deposition
  - ☐ Odours
  - ☐ Chemistry
  - ☐ Buildings
  - ☐ Complex terrain
- Odour units:** A dropdown menu showing 'ou\_e'.
- Enter parameters...:** Three buttons corresponding to the 'Chemistry', 'Buildings', and 'Complex terrain' options.
- Palette:** A dropdown menu showing 'Pollutants' and a 'Data...' button.
- Additional input file:** A checkbox and a text field, with 'Browse...' and 'Edit' buttons.

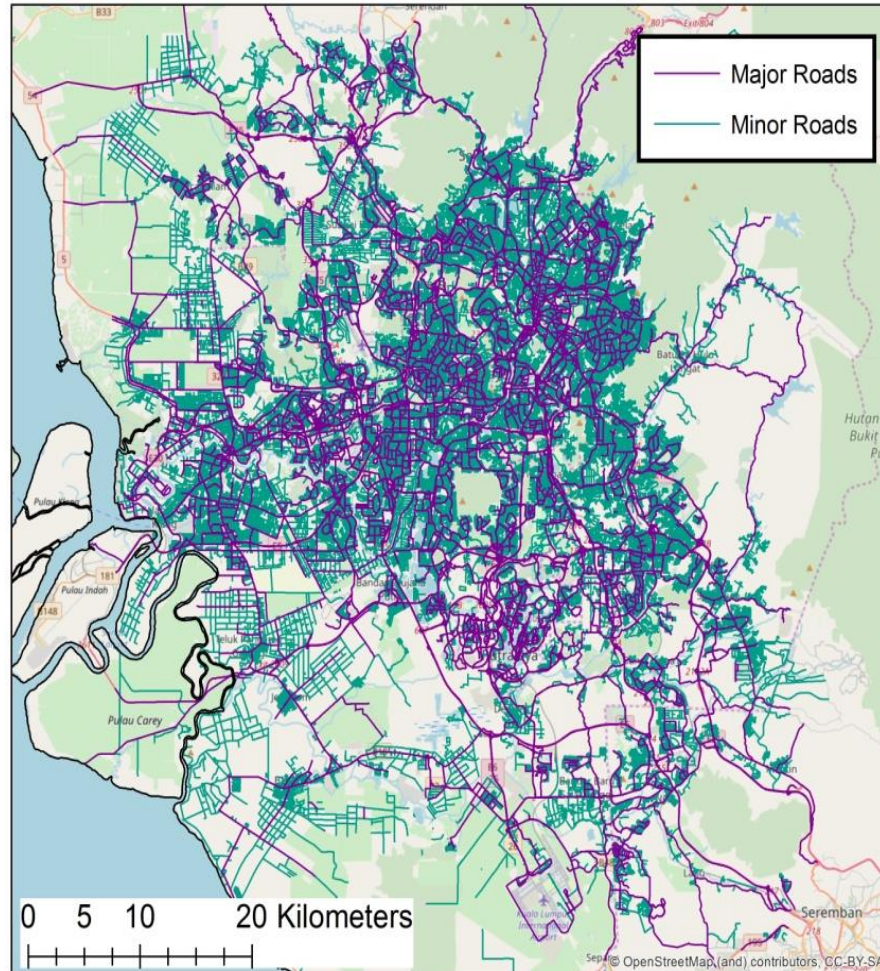
At the bottom of the window, there is a status bar with the text 'Enter the site name or other title (printed in output files)' and two input fields labeled 'Min:' and 'Max:'.



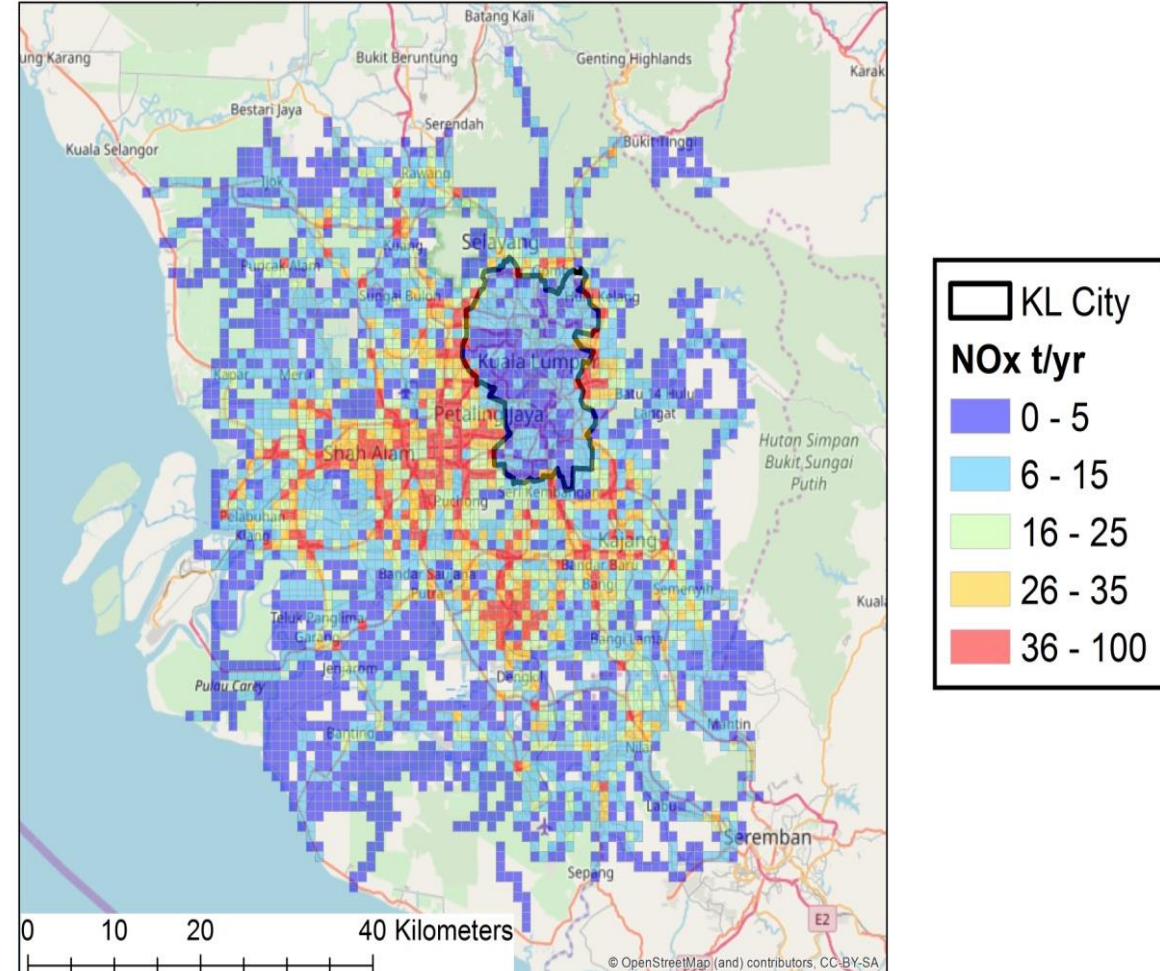
# Preparation on Input Data



## Preparation on Input Data : Traffic



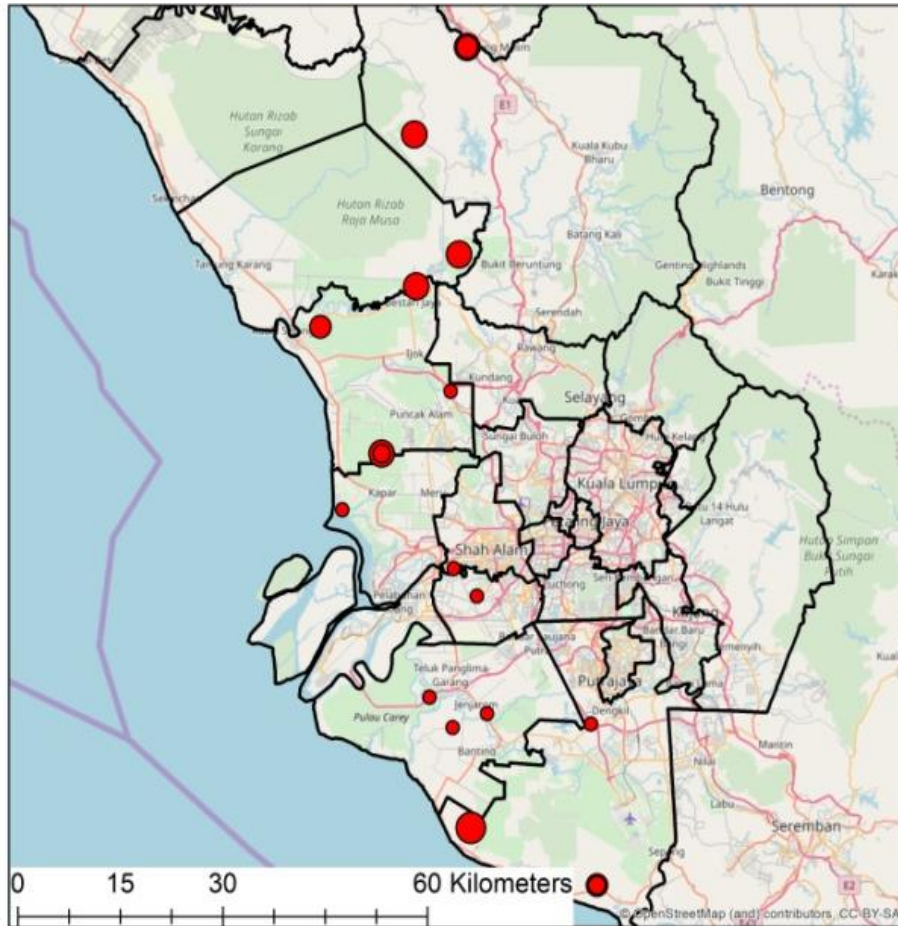
**Major and Minor Roads**



**Gridded Roads (1km x 1km) for NOx emissions**

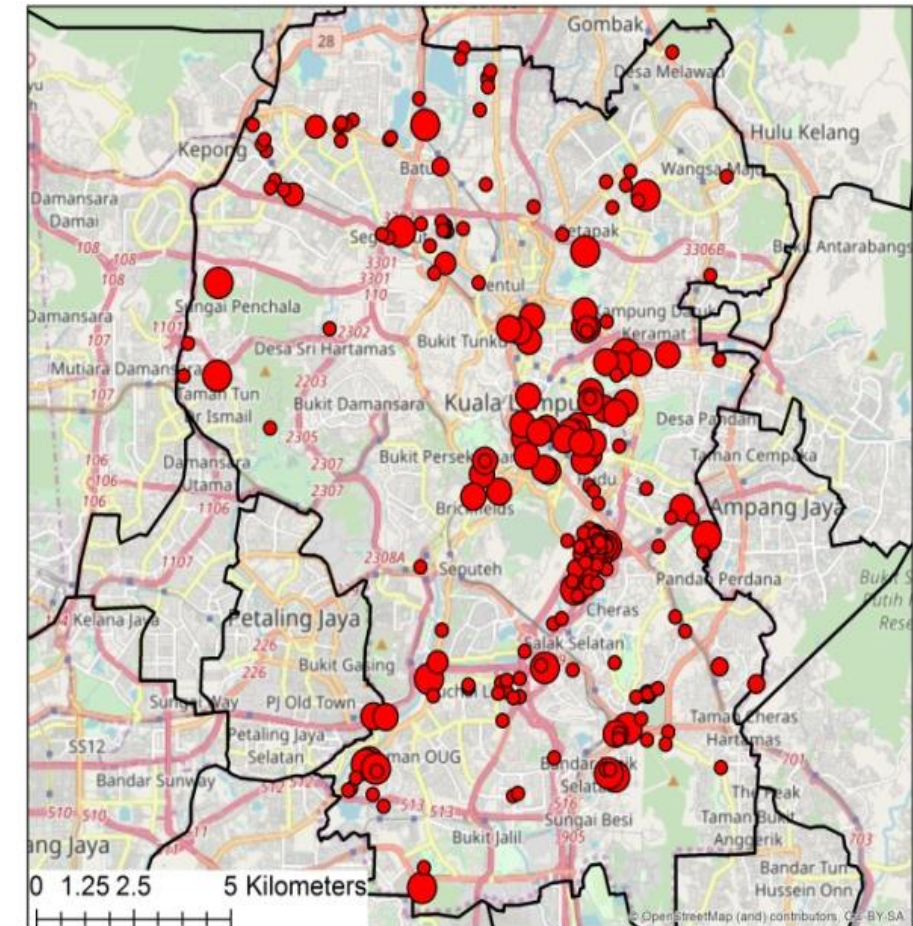


# Preparation on Input Data : Industrial



- Large industrial source locations indicating the relative  $PM_{10}$  emission rate

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- Small industrial source locations indicating the relative  $NO_x$  emission rate

© OpenStreetMap and contributors



# Preparation on Input Data

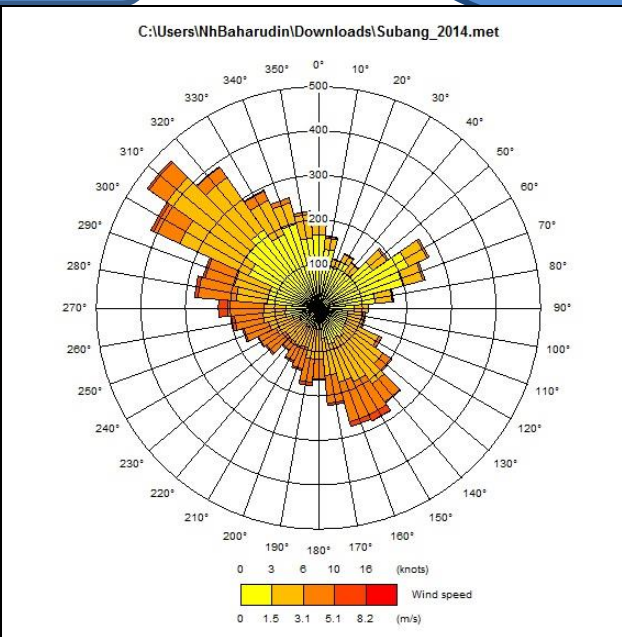
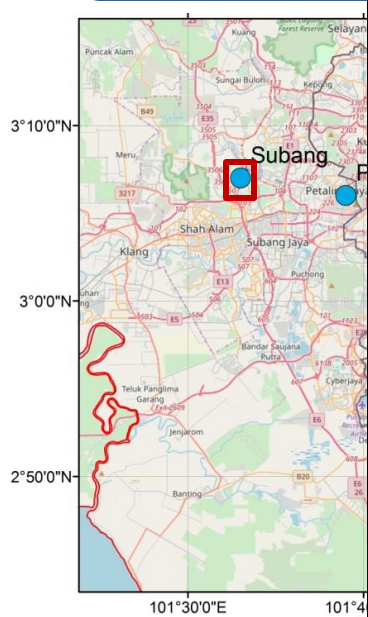


Meteorology



Background

ADMS-Urban



Sources

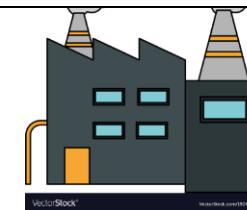
Annual average for 2014

No.	Station	CO	PM10	NO2	O3	SO2	NOx
1	Batu Muda	0.78	55.79	17.84	22.18	3.04	28.20
2	Cheras	0.82	49.13	20.59	21.55	2.12	34.33
3	Petaling Jaya	1.28	60.52	28.08	15.06	4.71	65.91
4	Klang	1.07	71.65	20.82	17.50	3.45	35.95
5	Shah Alam	0.82	55.01	24.12	19.61	2.74	40.48
6	<b>Banting</b>	<b>0.62</b>	<b>60.11</b>	<b>13.24</b>	<b>23.15</b>	<b>3.25</b>	<b>21.25</b>
7	Putrajaya	0.61	46.71	14.39	22.52	2.51	21.53
8	Nilai	0.62	63.93	15.07	15.61	6.11	25.18
9	<b>Tanjung Malim</b>	<b>0.45</b>	<b>40.76</b>	<b>7.97</b>	<b>19.54</b>	<b>1.14</b>	<b>13.11</b>

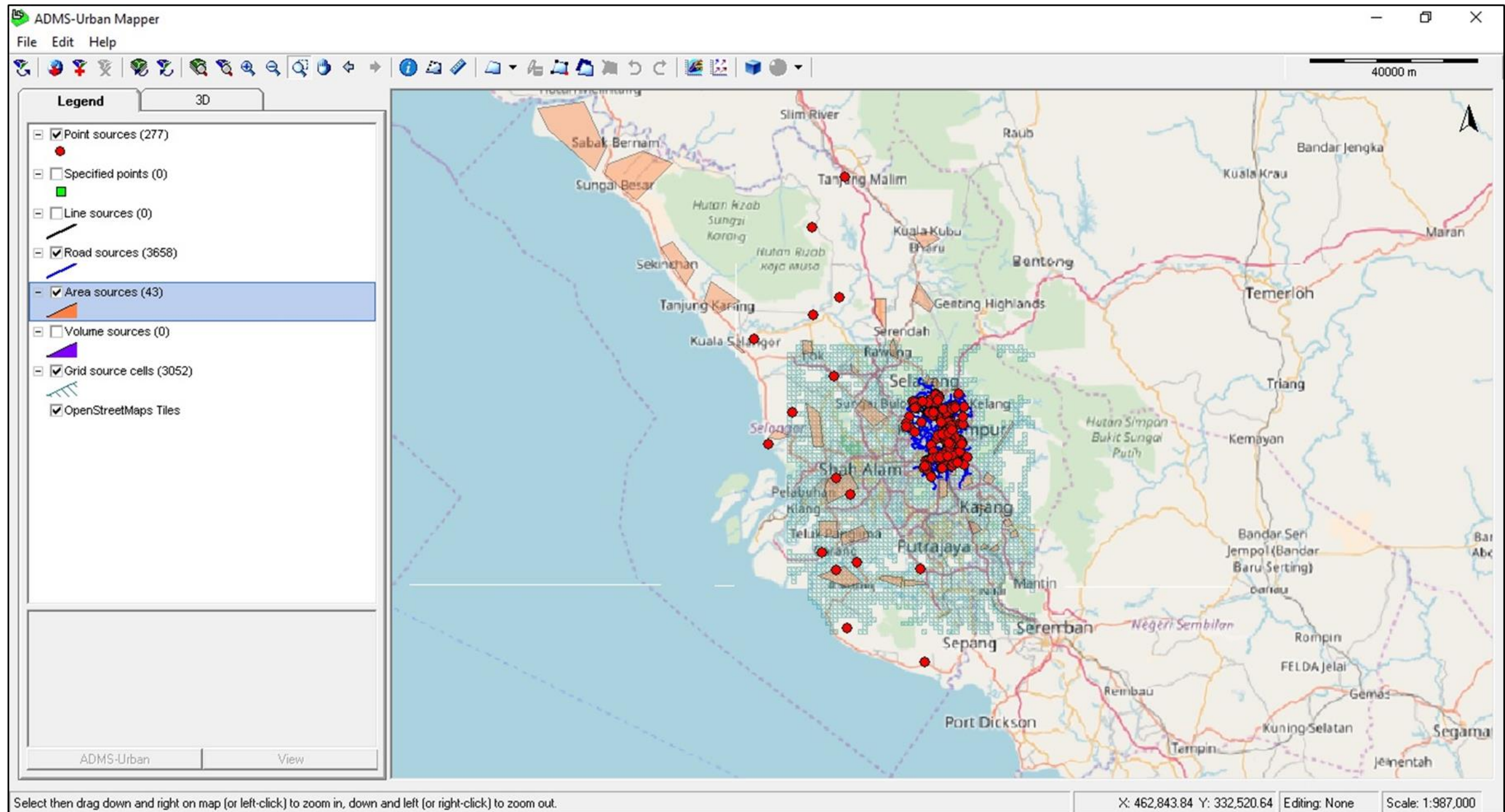


Traffic

Industrial

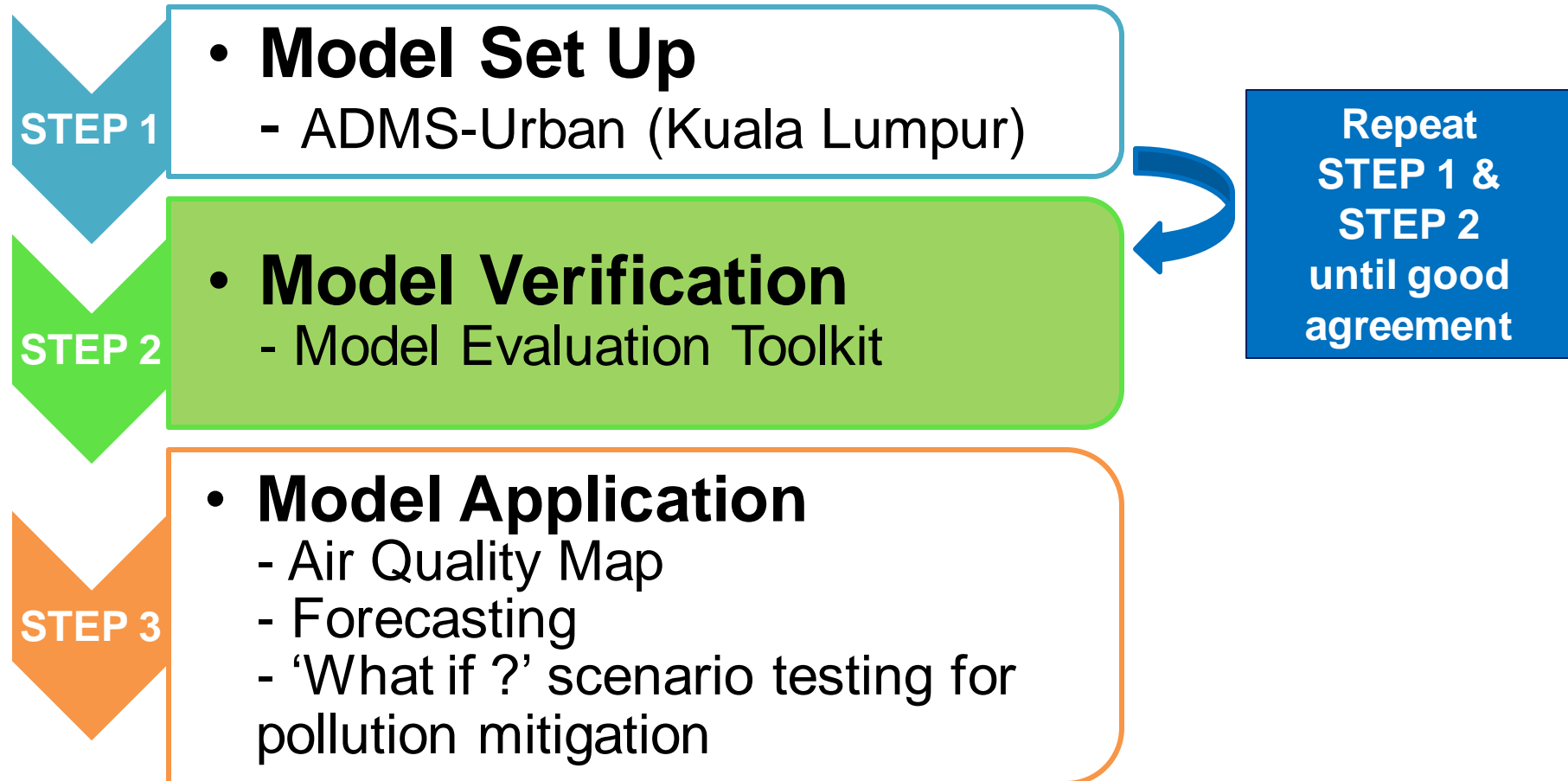


# Methodology



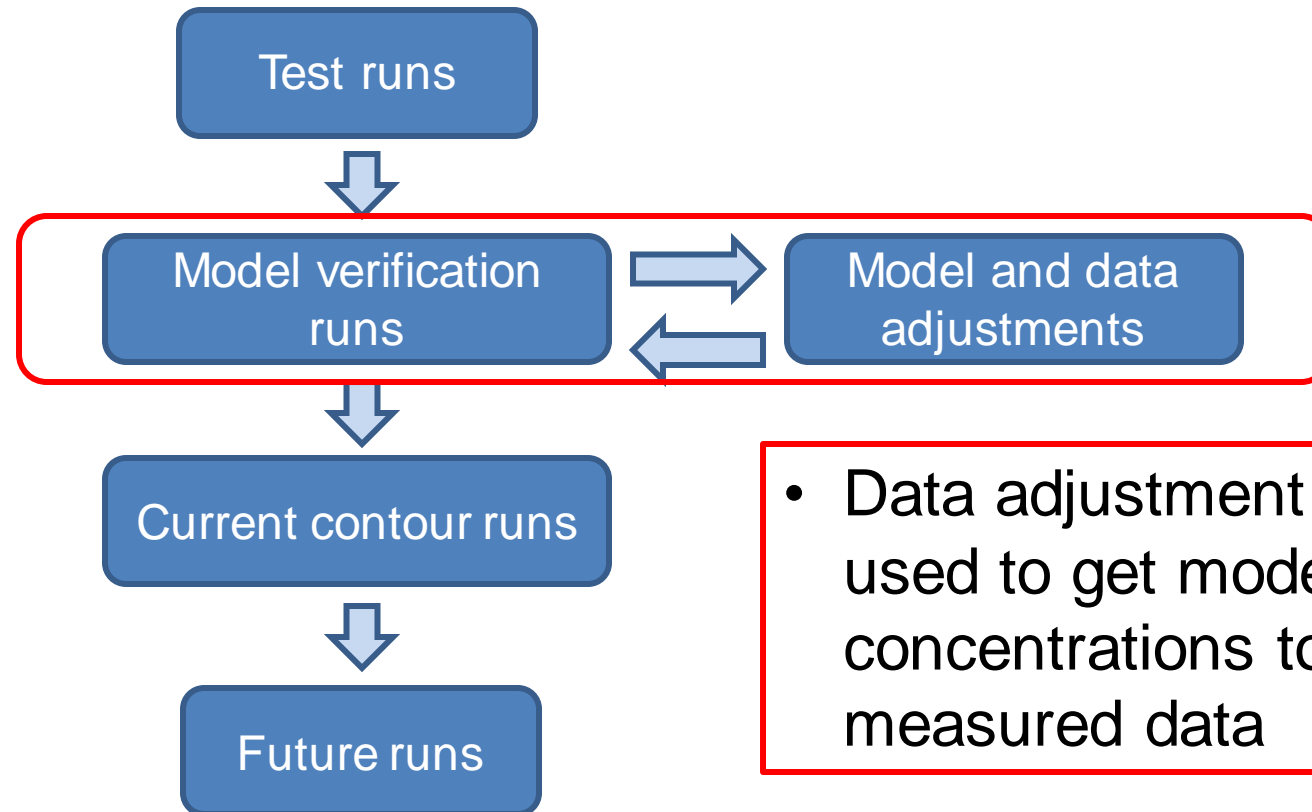
# Methodology

- How do we know the model gives the correct values?
  - **Compare the model predictions to reference measurements**



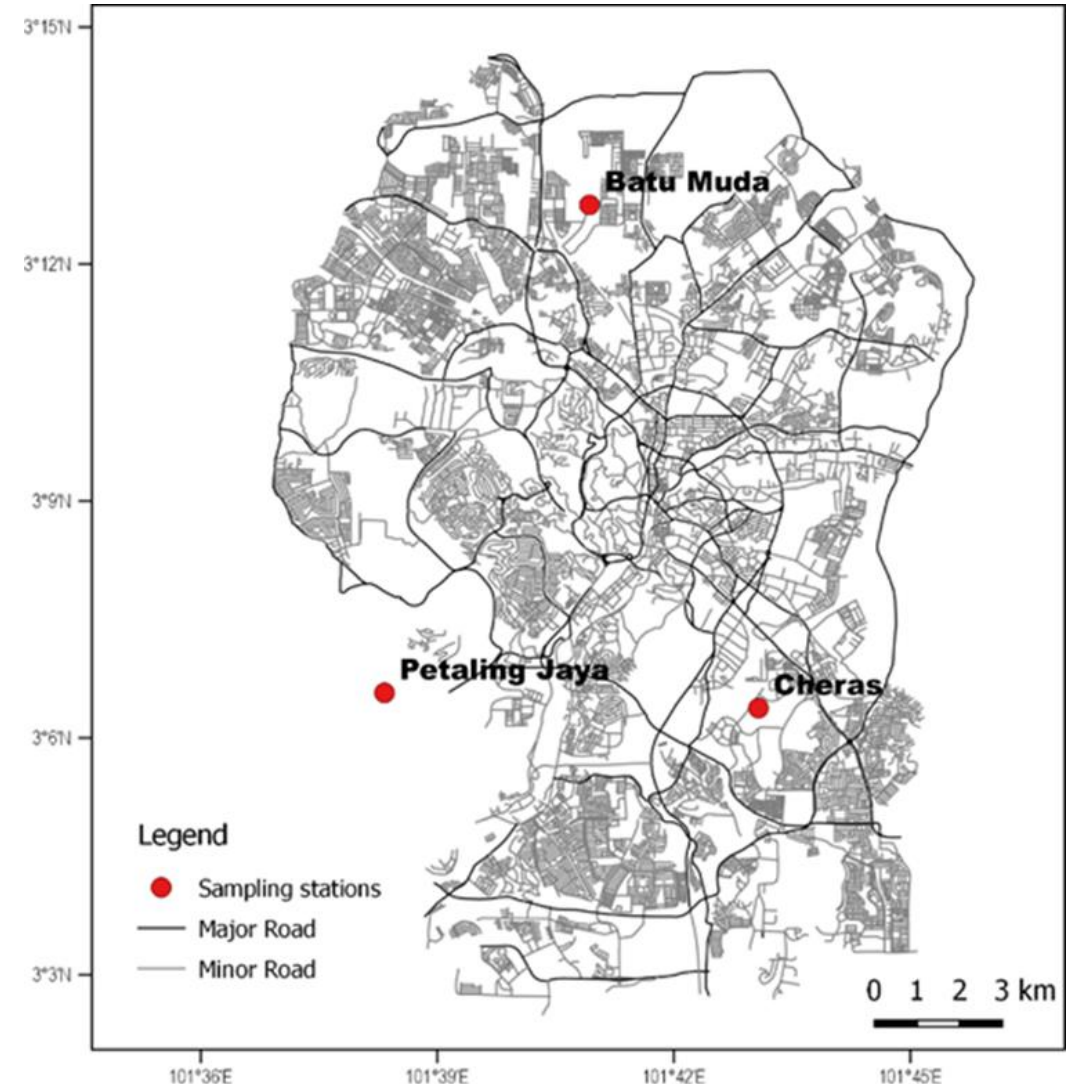
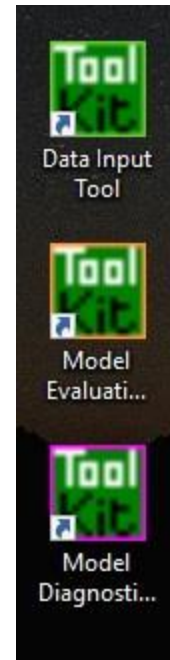


# Model Verification



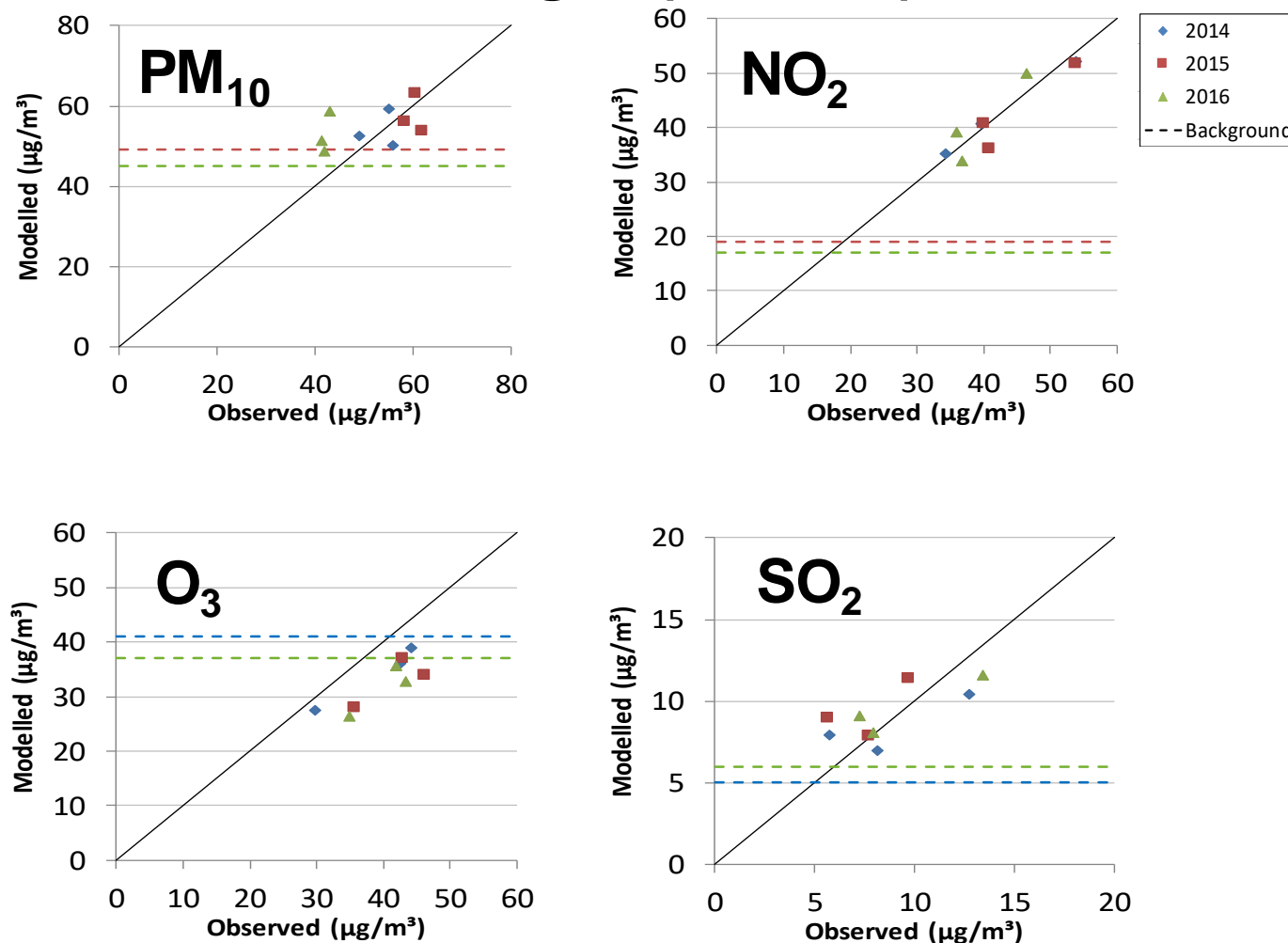
## Model Verification

- is process of comparing **calculated concentrations** with **measured data**
- Verification method:
  - **Model Evaluation Toolkit**
- **2 stations in KL :**
  1. Cheras
  2. Batu Muda
- **1 station near to KL:**
  1. Petaling Jaya



# Model Verification

## Annual averages (2014-16)



## Statistics for hourly predictions

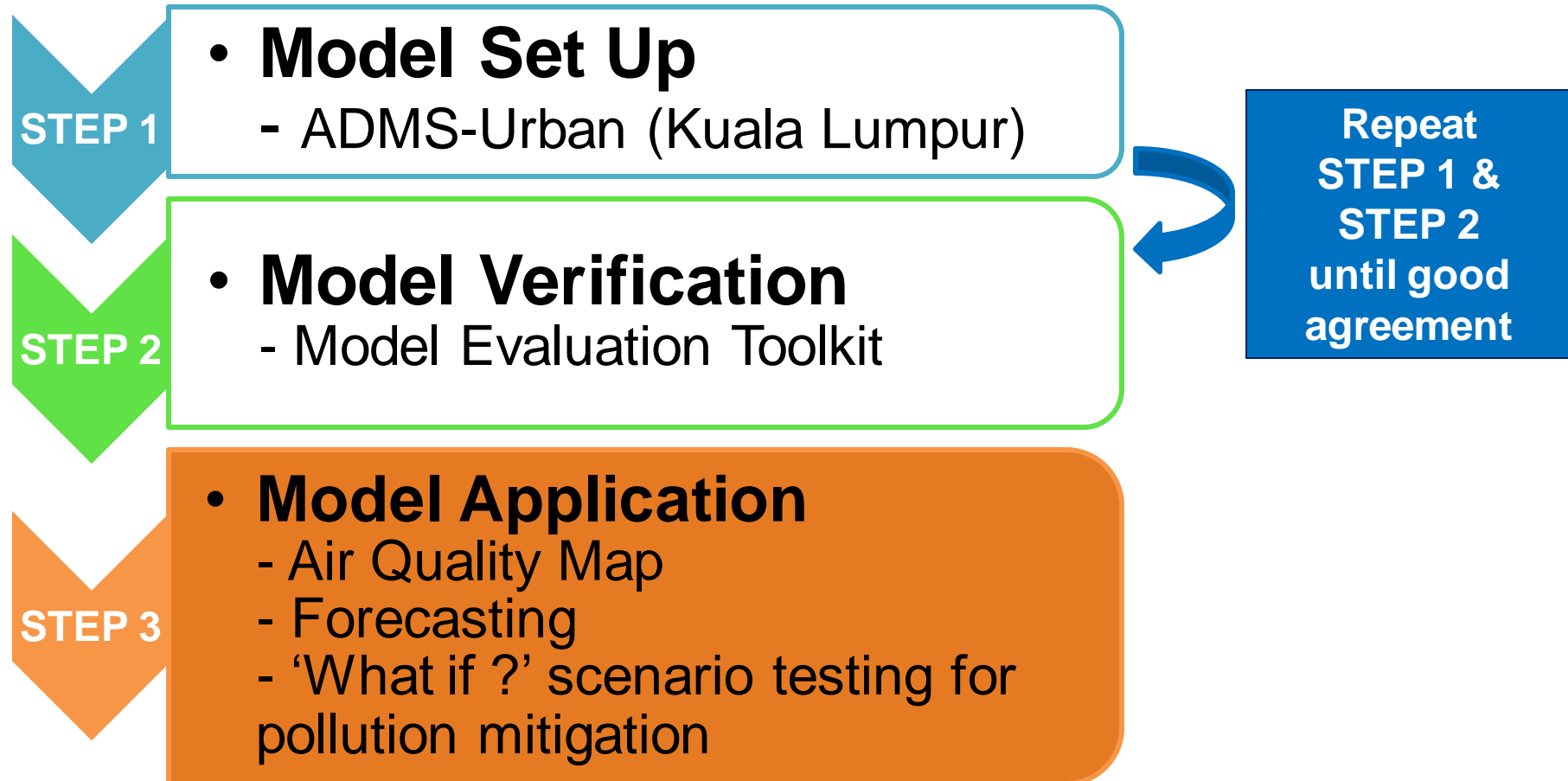
Poll.	Year	Fb	NMSE	R
PM <sub>10</sub>	2014	0.01	0.38	<b>0.62</b>
	2015	-0.05	0.31	<b>0.76</b>
	2016	0.23	0.25	<b>0.55</b>
NO <sub>2</sub>	2014	0.00	0.27	<b>0.52</b>
	2015	-0.05	0.29	<b>0.45</b>
	2016	0.03	0.29	<b>0.46</b>
NO <sub>x</sub>	2014	-0.03	0.39	<b>0.62</b>
	2015	0.05	0.35	<b>0.61</b>
	2016	0.05	0.39	<b>0.56</b>
O <sub>3</sub>	2014	-0.12	0.62	<b>0.81</b>
	2015	-0.24	0.70	<b>0.80</b>
	2016	-0.24	0.70	<b>0.79</b>
SO <sub>2</sub>	2014	-0.05	1.24	<b>0.21</b>
	2015	0.20	1.78	<b>0.15</b>
	2016	0.00	1.15	<b>0.18</b>

Fb = Fractional bias,  
 NMSE = normalised mean square error,  
 R = correlation

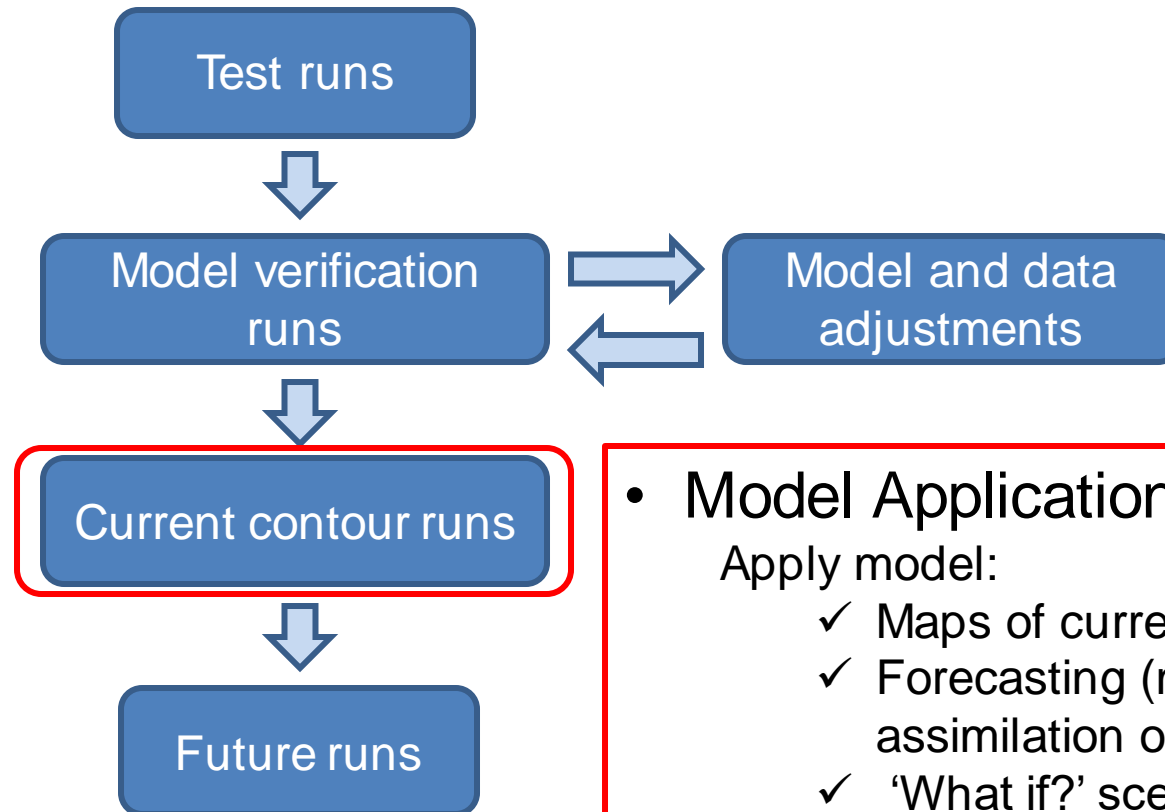


# Methodology

- How do we know the model gives the correct values?
  - **Compare the model predictions to reference measurements**



## Model Verification



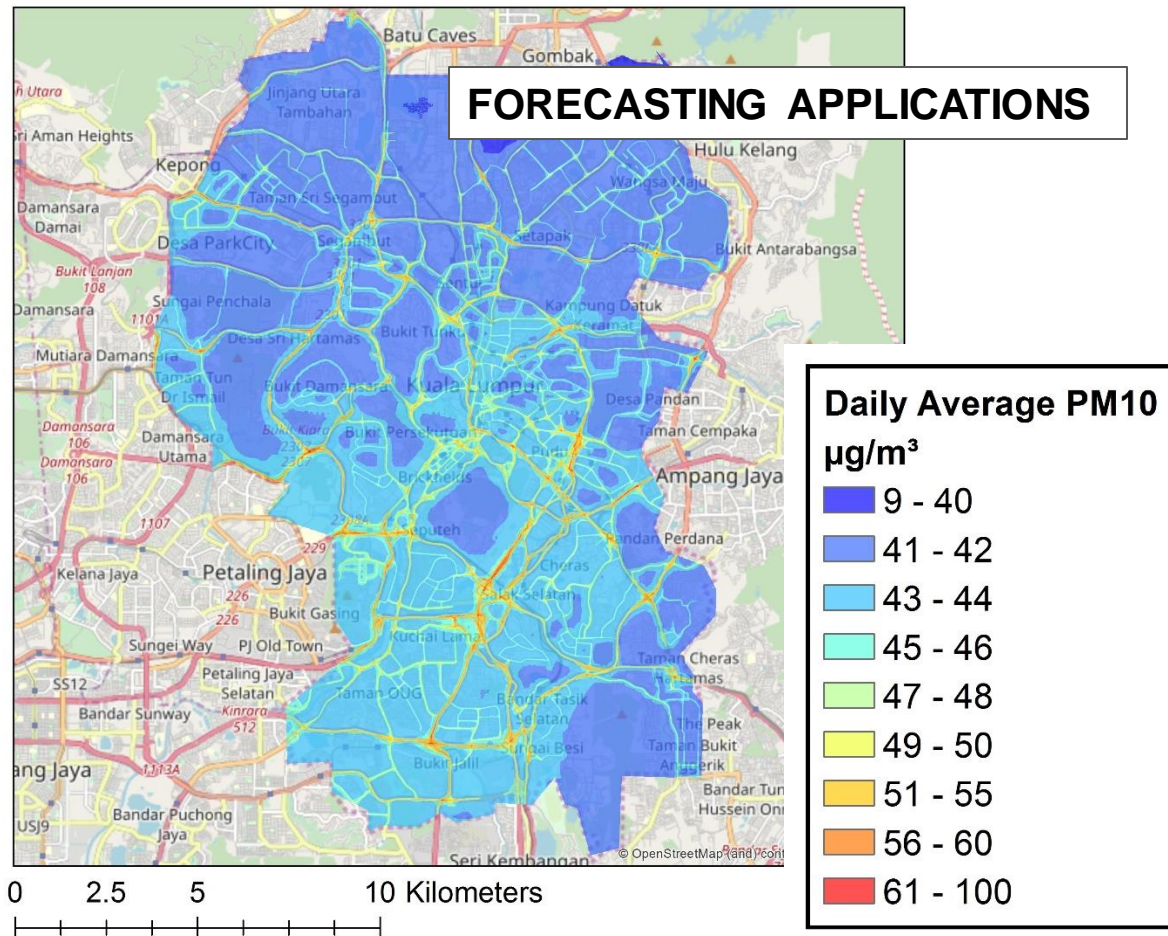
- **Model Application**

Apply model:

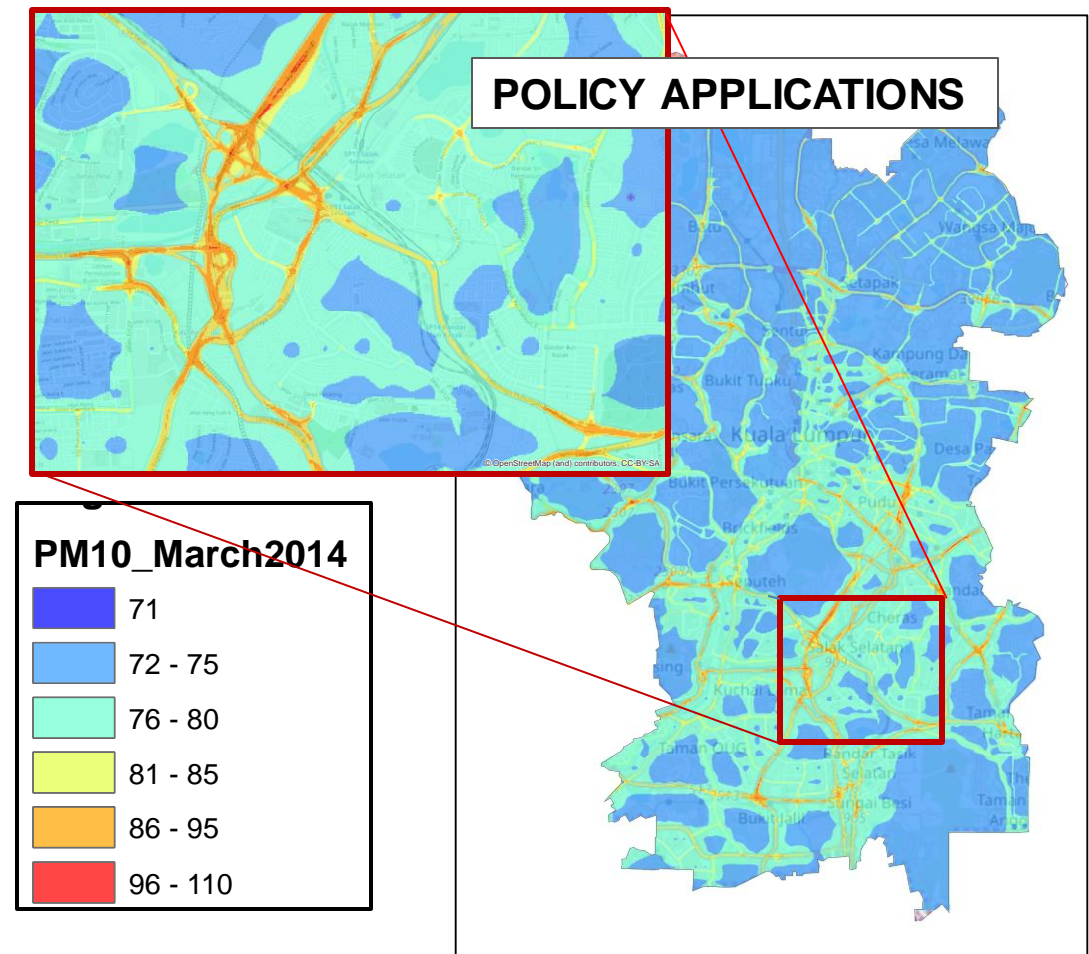
- ✓ Maps of current air quality
- ✓ Forecasting (measurement data assimilation optional)
- ✓ 'What if?' scenario testing for pollution mitigation

## Air Quality Maps

- Daily PM<sub>10</sub> concentrations



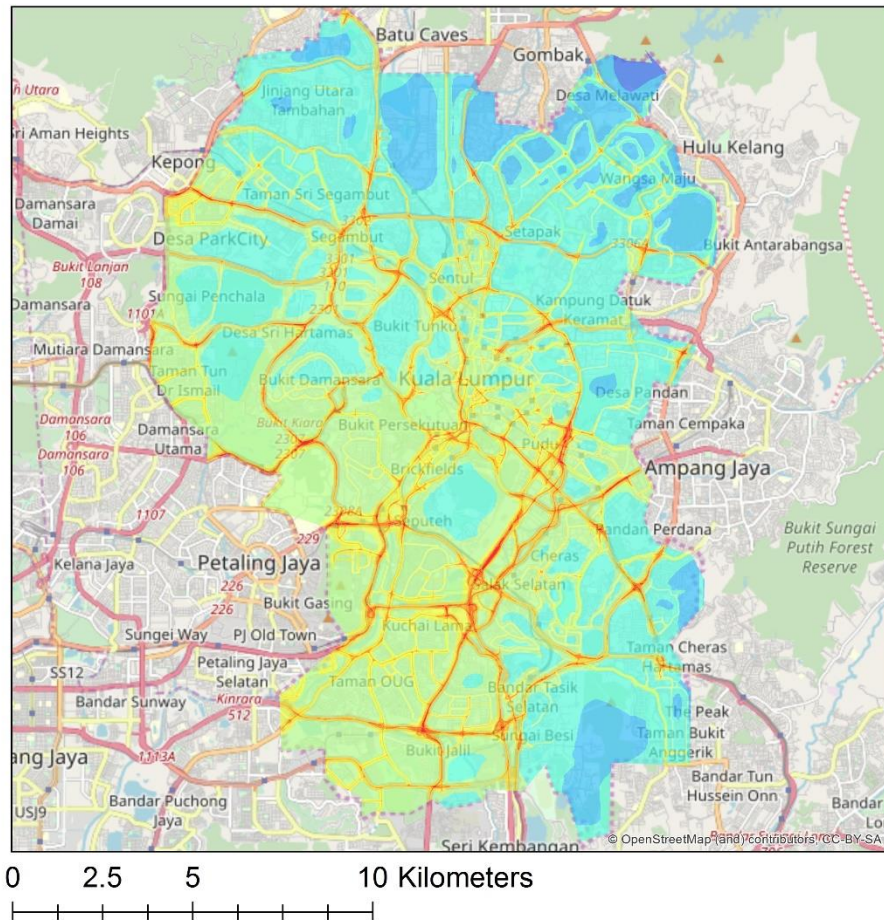
- March 2014 PM<sub>10</sub> concentrations



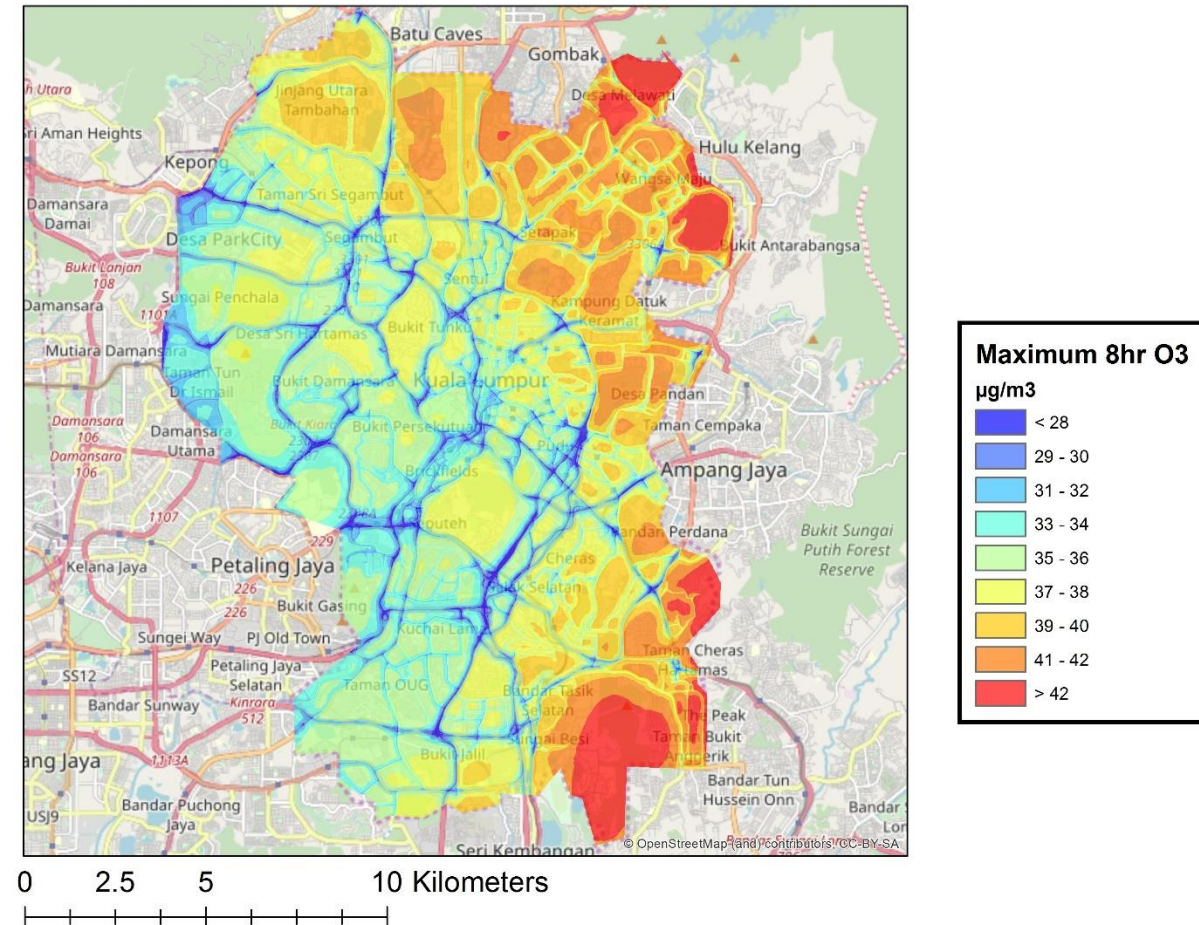


## Air Quality Maps

- Daily NO<sub>2</sub> concentrations



- Daily O<sub>3</sub> concentrations

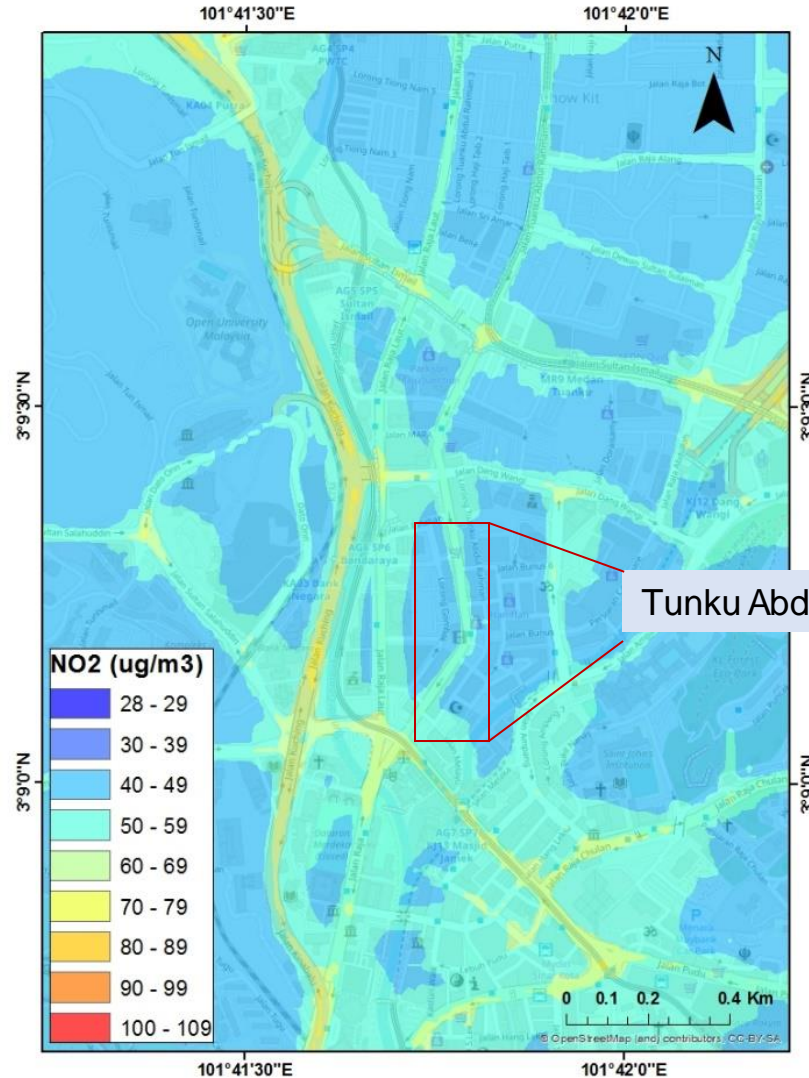




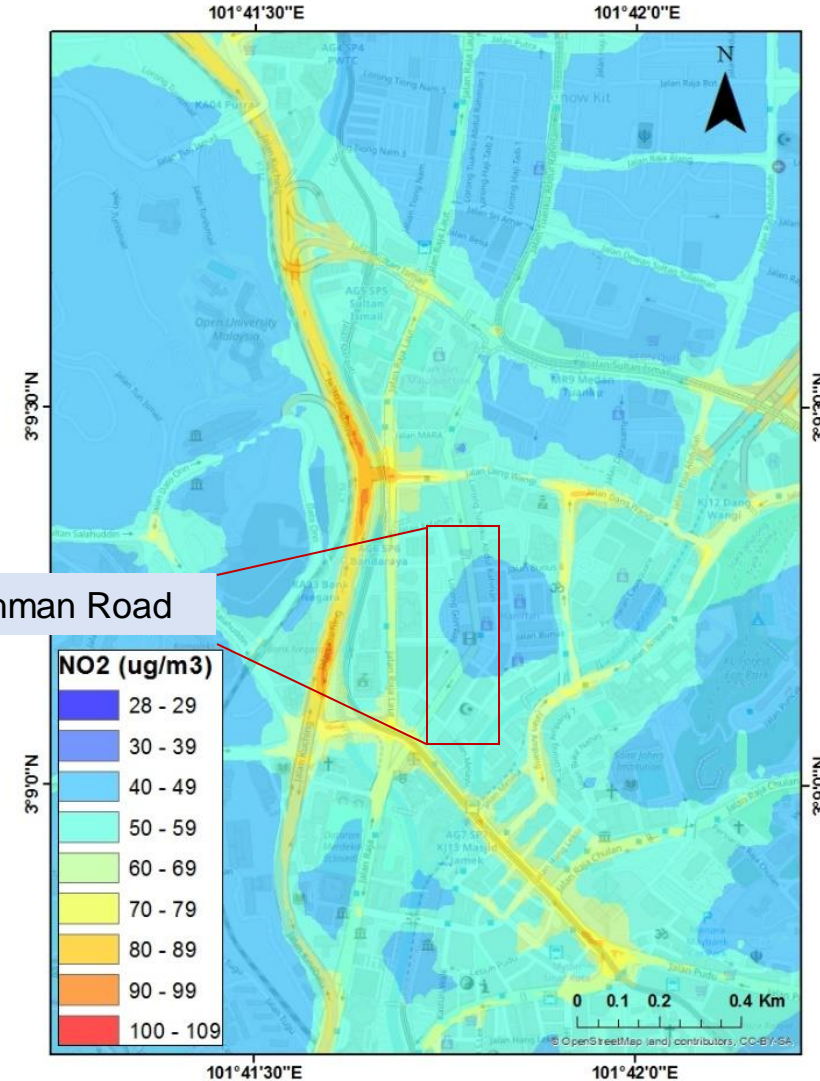
# SCENARIO ROAD CLOSURE IN KUALA LUMPUR

Tunku Abdul Rahman Road

Before road closure



After road closure

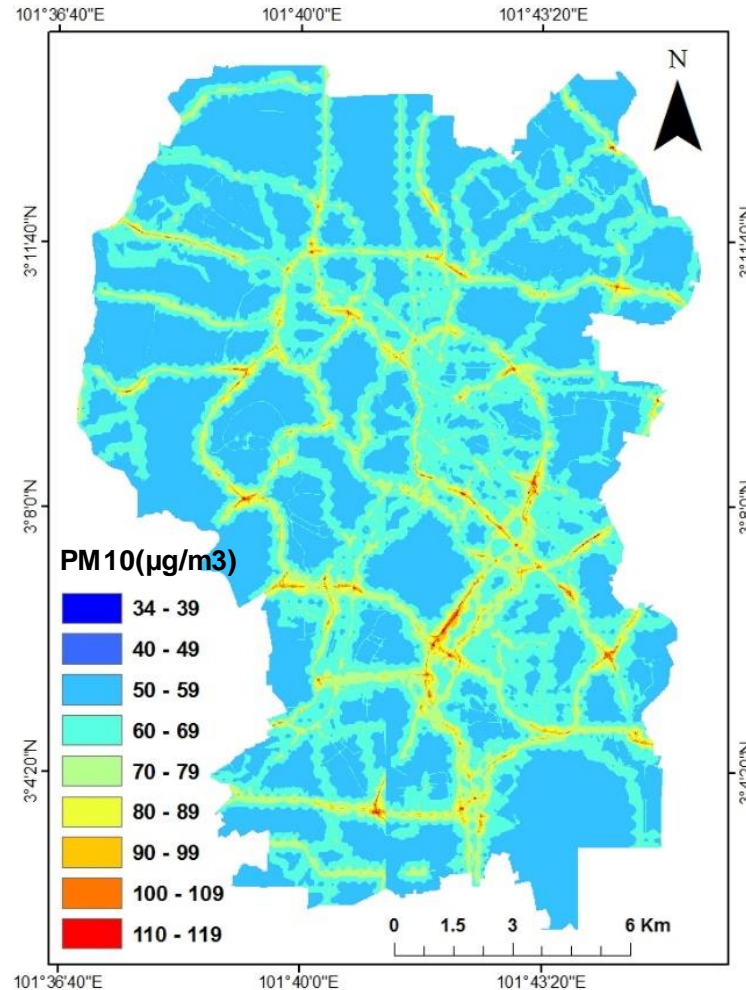


Daily average concentrations of NO<sub>2</sub> (ug/m<sup>3</sup>) before and after Tunku Abdul Rahman road closure

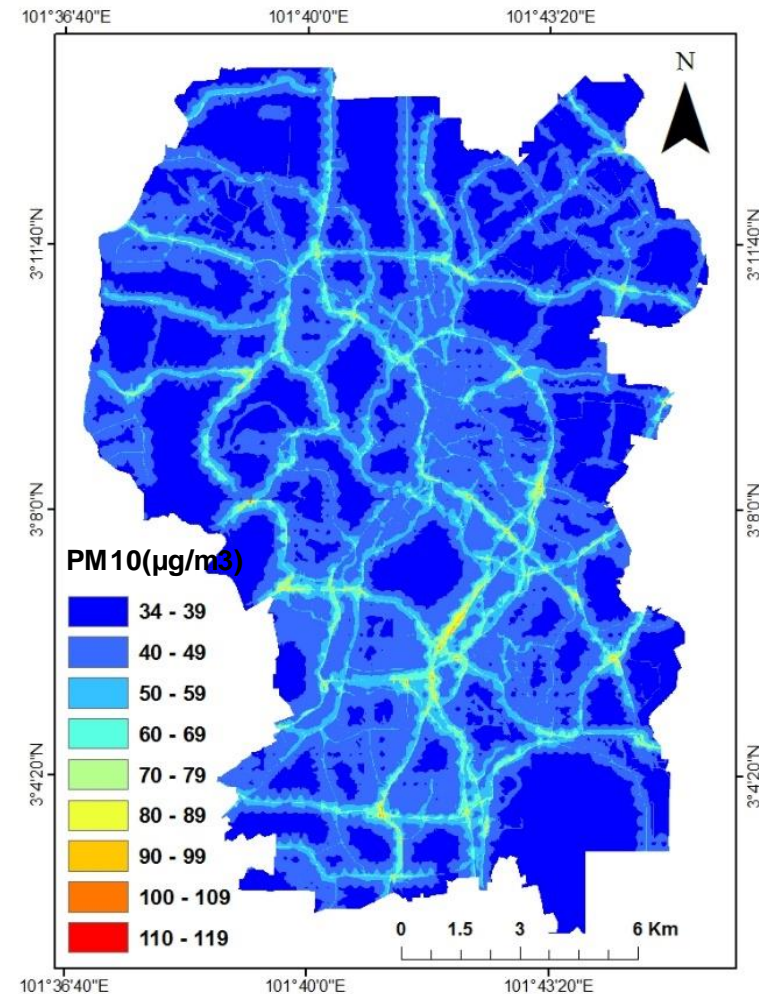
# SCENARIO HAZE IN KUALA LUMPUR

Haze (2015) & Non-Haze Year (2016)

Haze year (2015)



Non-Haze year (2016)

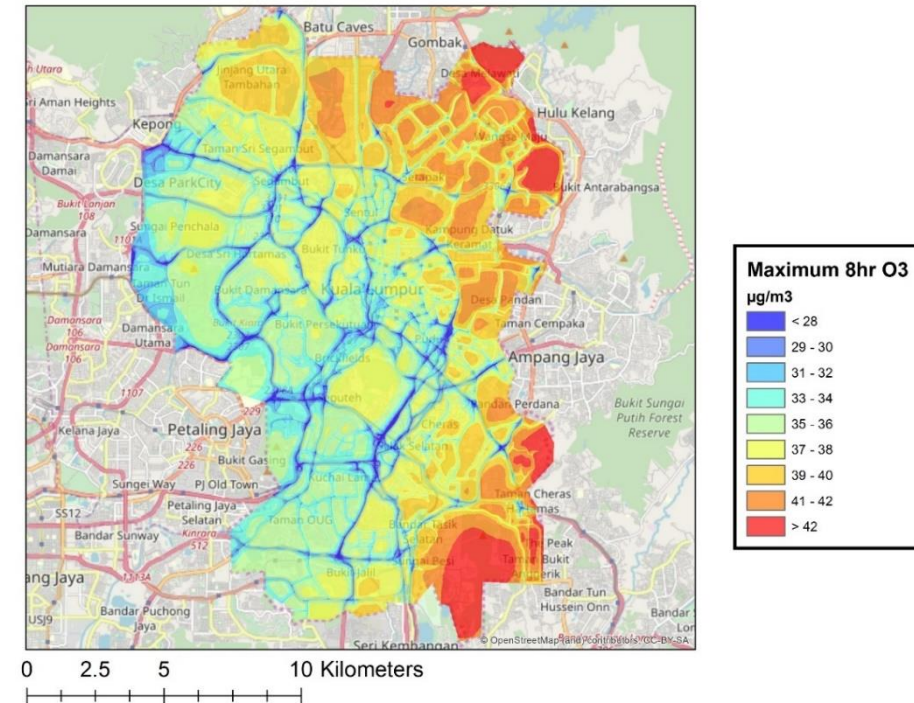


Daily average concentrations of PM<sub>10</sub> (µg/m<sup>3</sup>) for haze and non-haze year



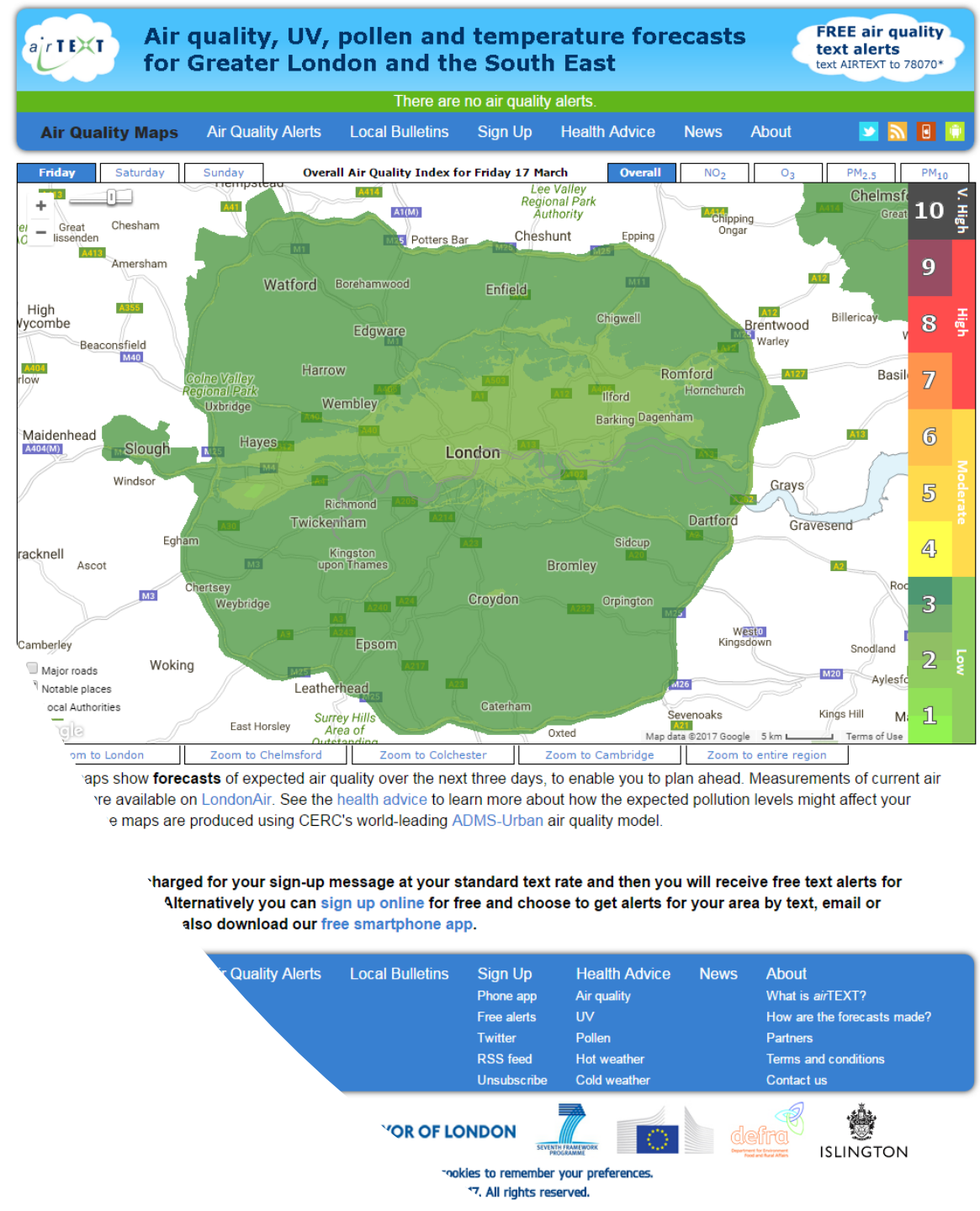
# Summary

- Model predictions of air quality pollutants compare generally **well** with measurements, particularly for **PM<sub>10</sub>, O<sub>3</sub>, NO<sub>x</sub> & NO<sub>2</sub>** (R=0.62,0.52,0.62 & 0.81 respectively).
- The emissions inventory has some **limitations**.
- **Improvement** of emission inventory will lead to **better model prediction**.



# Summary

- Current model setup will be ready for provision of **detailed street-level air quality forecasts** – improving resilience to atmospheric hazards in Kuala Lumpur
- Future application:
  - air quality and health impact assessments** of proposed developments or urban planning
  - air pollution exposure studies**
  - developing and testing policy and action plans** for air quality improvement such as Clean Air Zones or Low Emission Zones
  - assessment** of modelled air quality **against air quality standards and limit values** including those from WHO, EU, UK, USA and China
  - investigation** of air quality management options **for the full range of source types** including transport sources





**Thank you for your attention!**