

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

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Sciences and Applications to Air Quality***

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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**

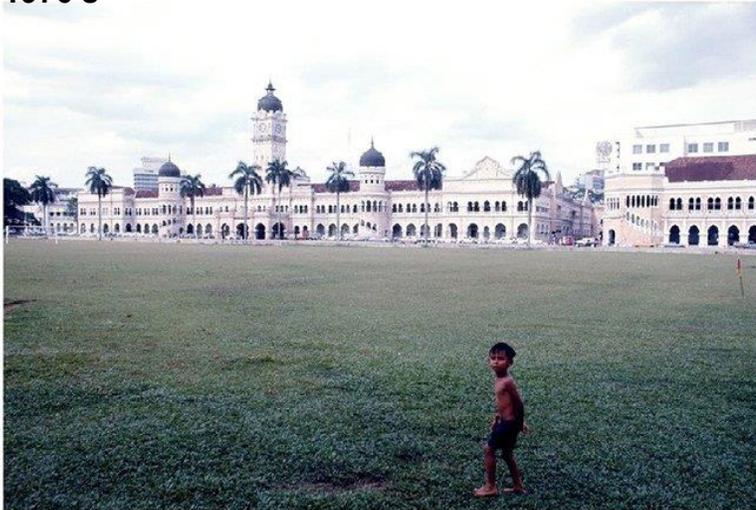


Kuala Lumpur

Introduction

Dataran Merdeka

1970's



Chow Kit Road

1970's



2017's

Jalan Sultan Ismail

1970's



2017's



2017's

Urban Atmosphere

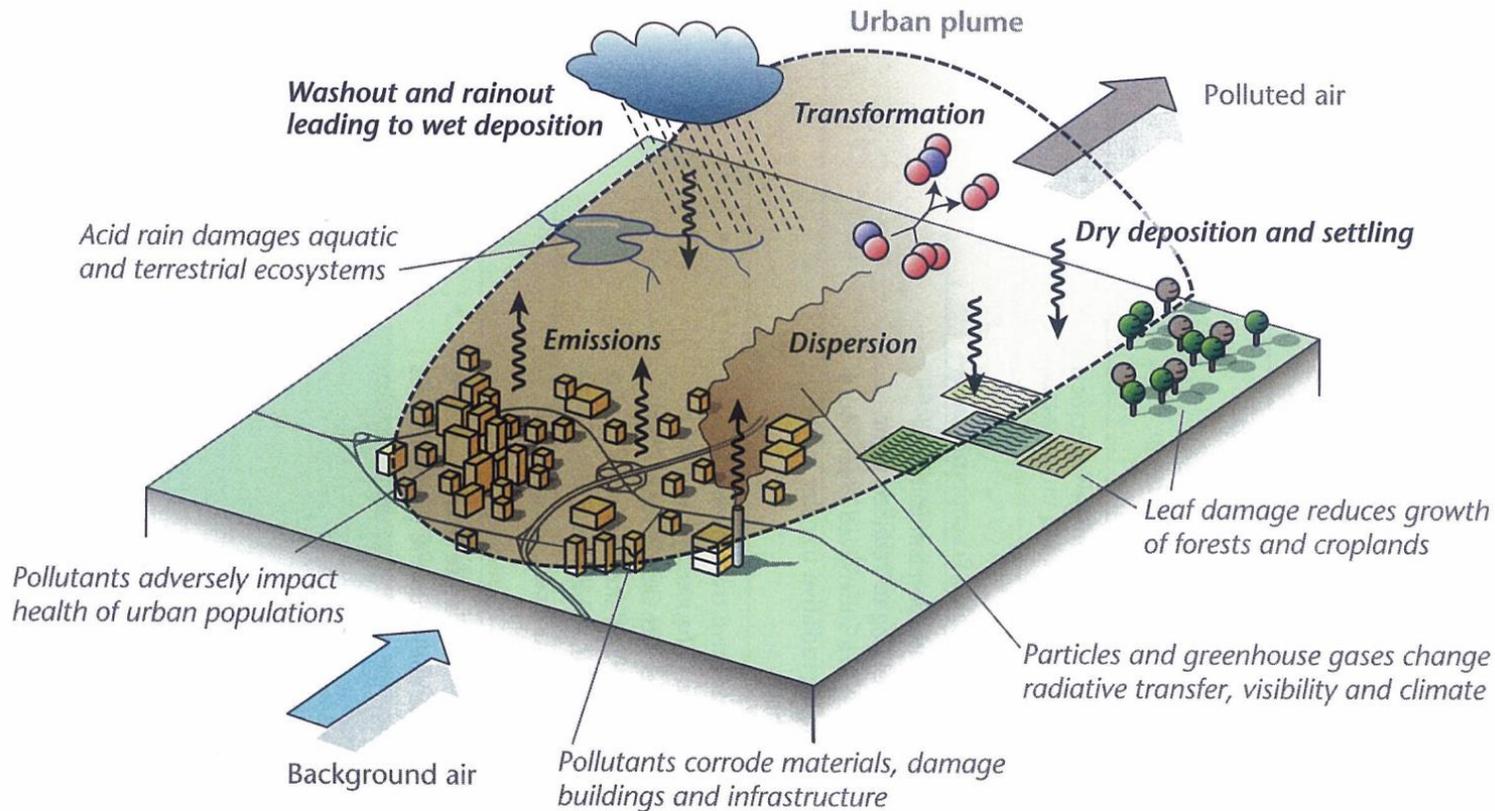
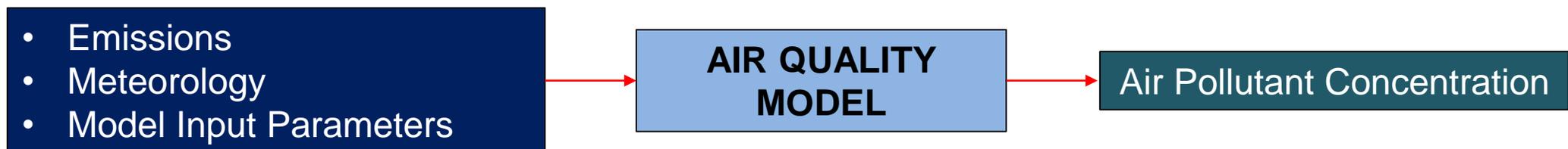


Figure : The 'life cycle' of air pollutants in the urban plume, with relevant processes regulating air pollutant concentrations in black and impacts of pollutants in grey italics.

- **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

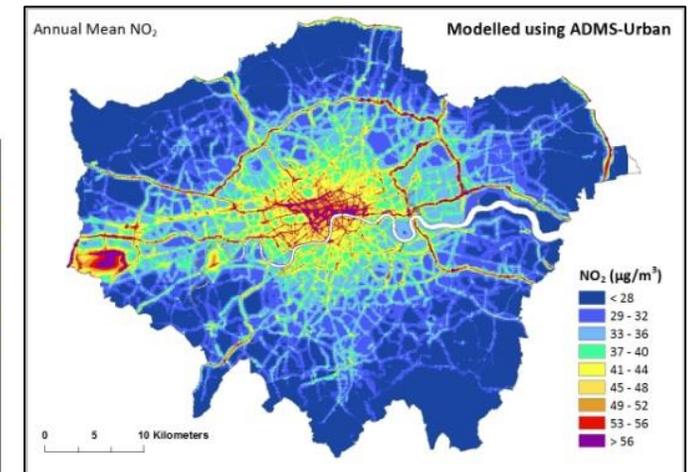
- Air Quality Models are **mathematical formulations** that include parameters that affect pollutant concentrations
- Air pollution modeling is a **numerical tool** used to describe the causal relationship between **emissions, meteorology**, atmospheric concentrations, deposition, and other factors.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



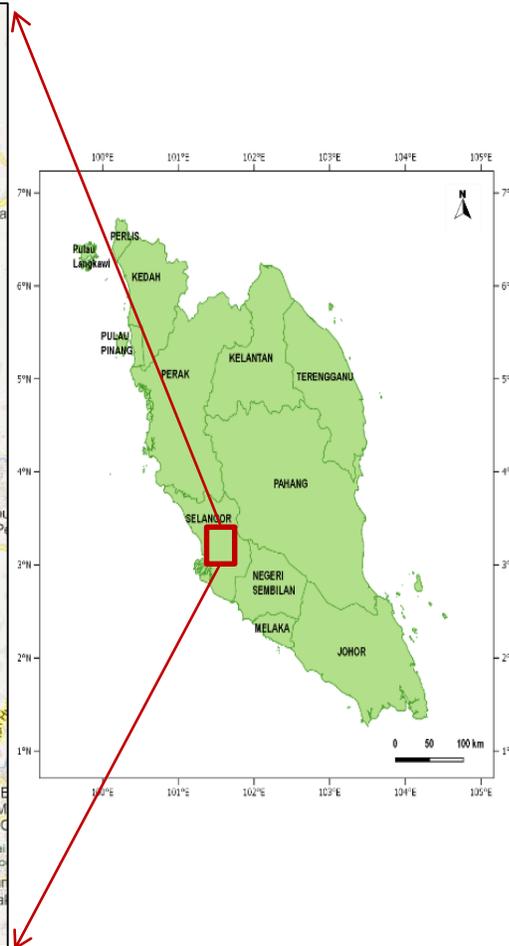
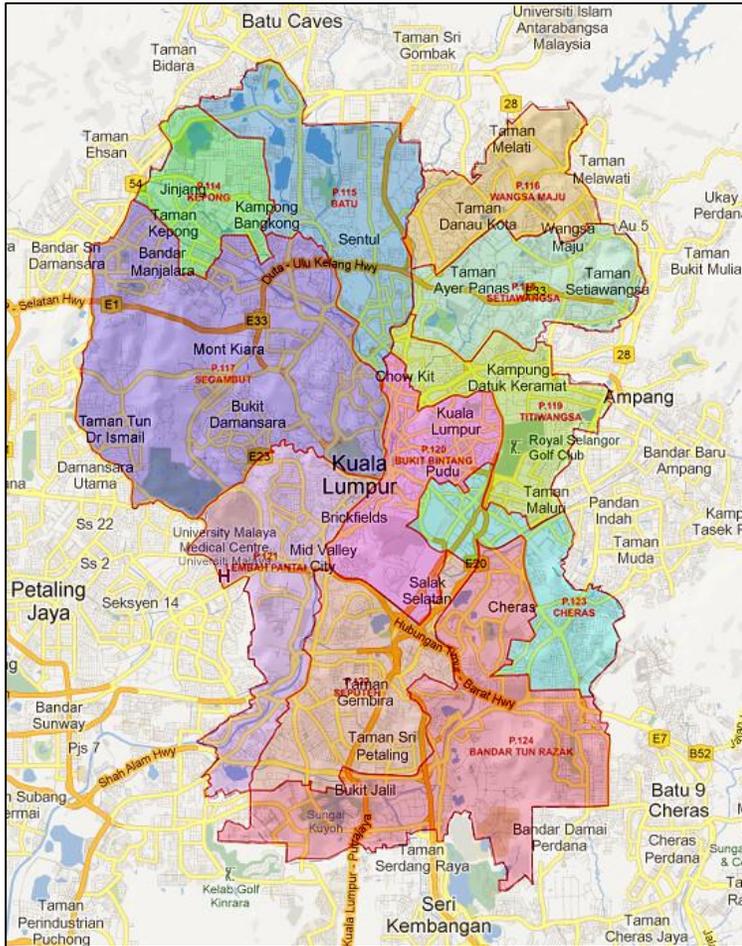
ADMS-Urban

- 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

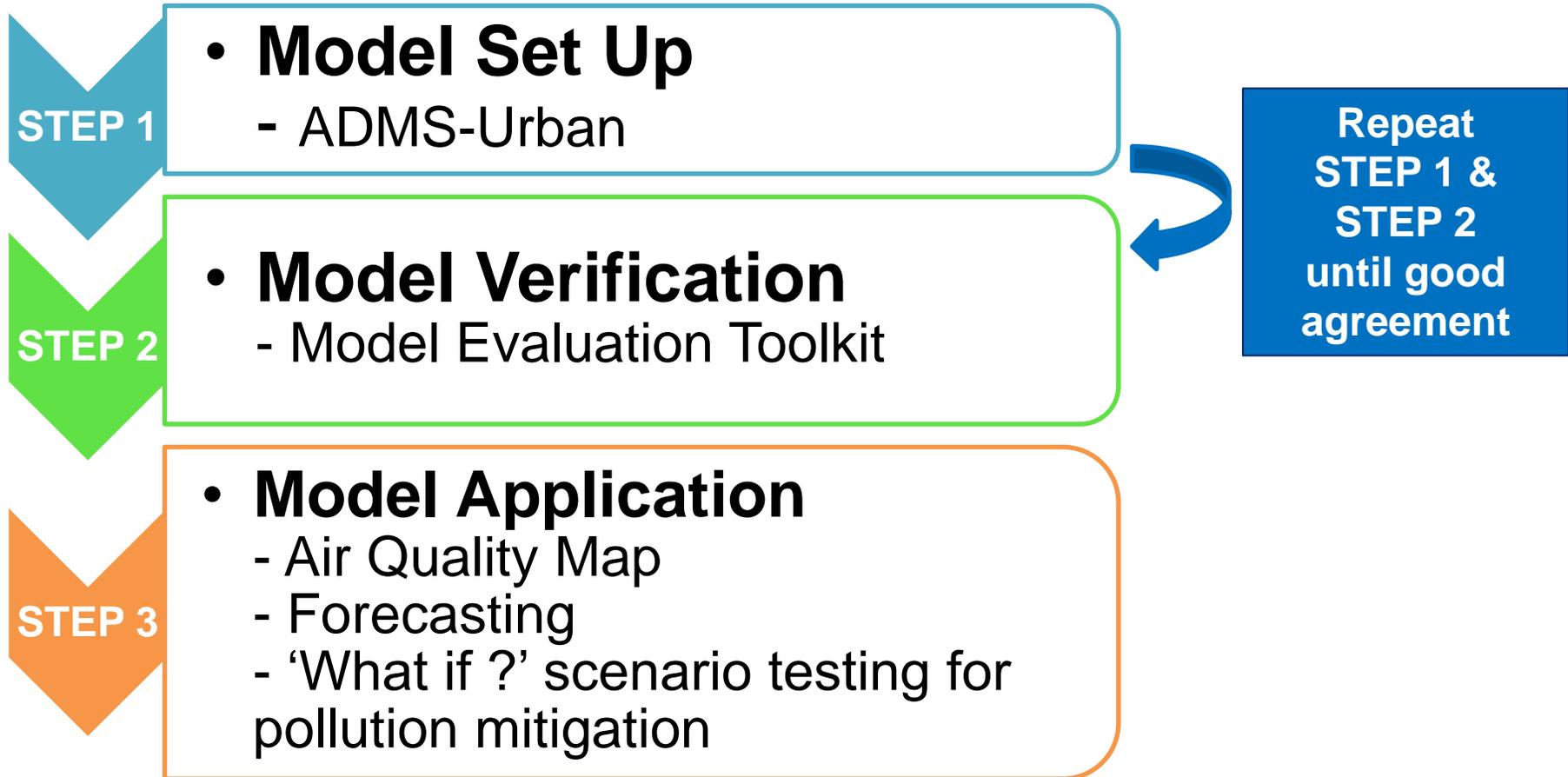


to model the level of air quality by using ADMS-Urban in Kuala Lumpur

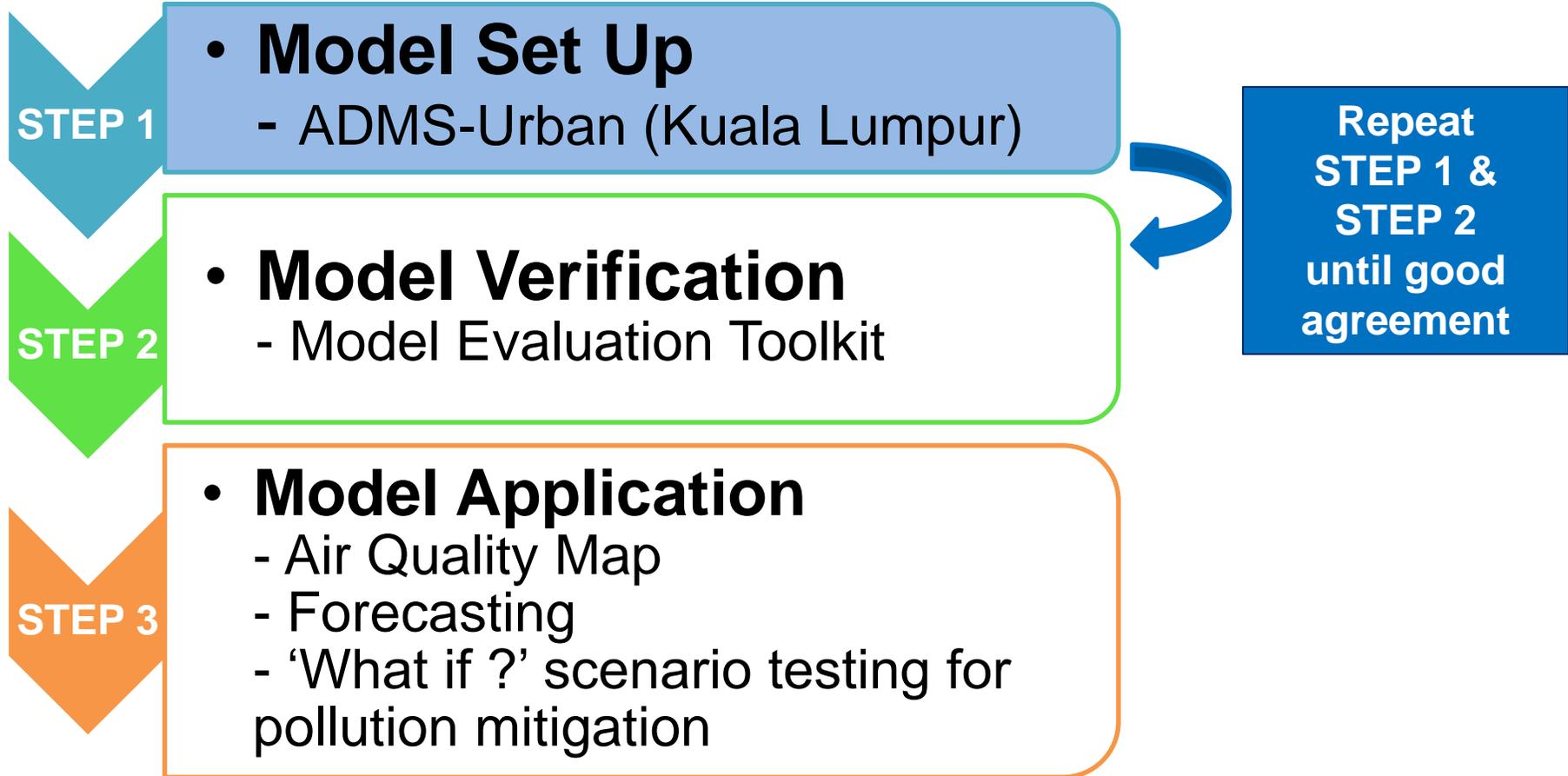


to assess local emission from different emission sources for modelling air quality in Kuala Lumpur

Methodology

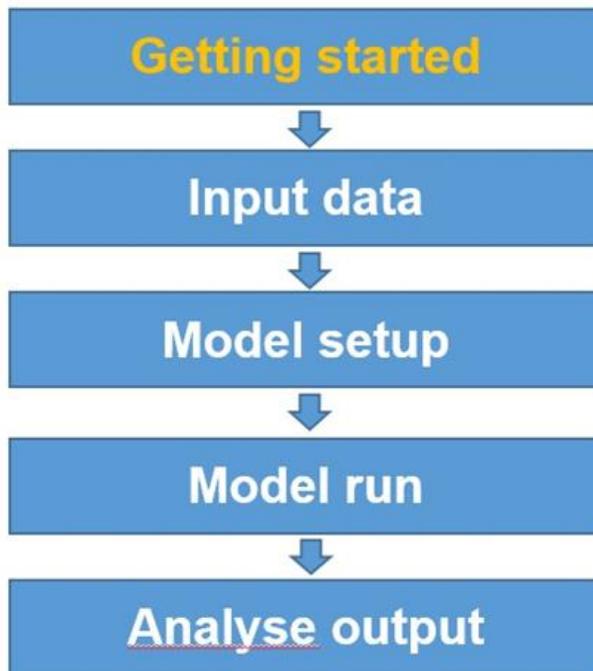


Methodology

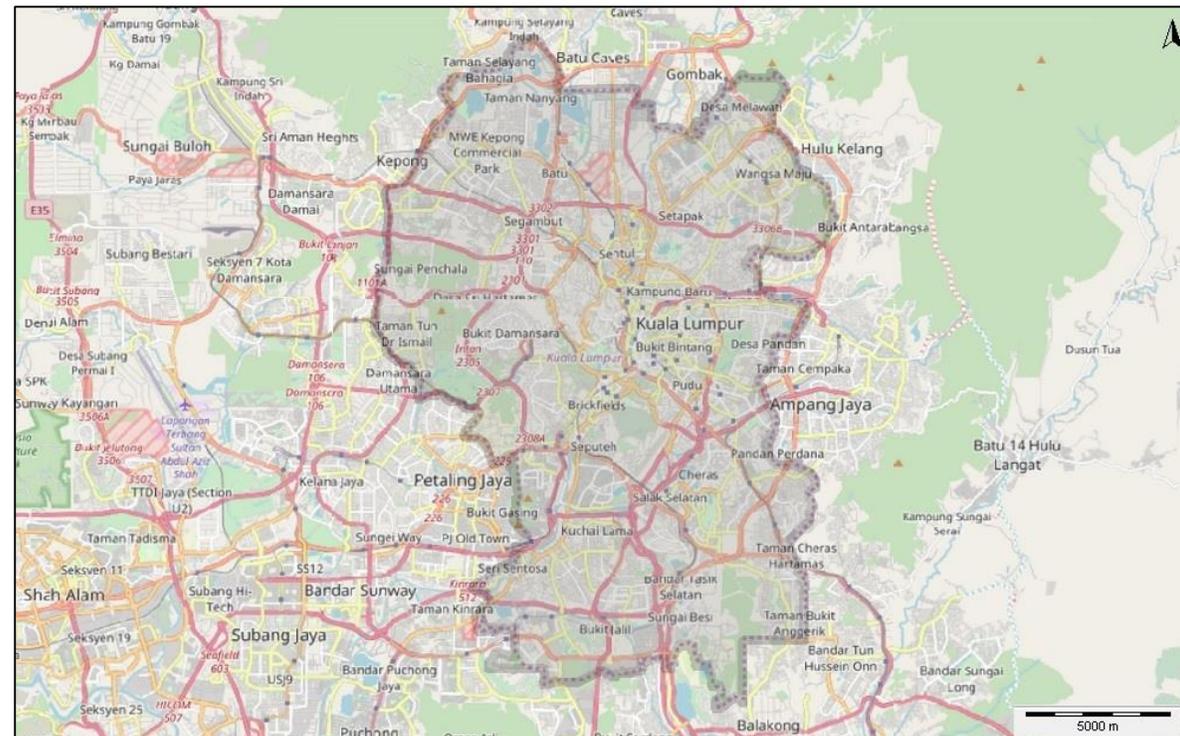


Model Set Up

ADMS-Urban



- Domain : **Kuala Lumpur**
- Year : **2014**
- ADMS-Urban Model : **Version 4.1.1**
- Air pollutants : **NO_x, NO₂, PM₁₀, O₃ & SO₂**



Preparation on Input Data

ADMS-Urban

Getting started

Input data

Model setup

Model run

Analyse output

(new file)

File Run! Results Utilities Emissions inventory Help

Setup Source Meteorology Background Grids Output

Name of site

Name of project

Coordinate system Unspecified regular Cartesian

Model options

- Dry deposition
- Wet deposition
- Odours Odour units ou_e
- Chemistry Enter parameters...
- Buildings Enter parameters...
- Complex terrain Enter parameters...

Palette

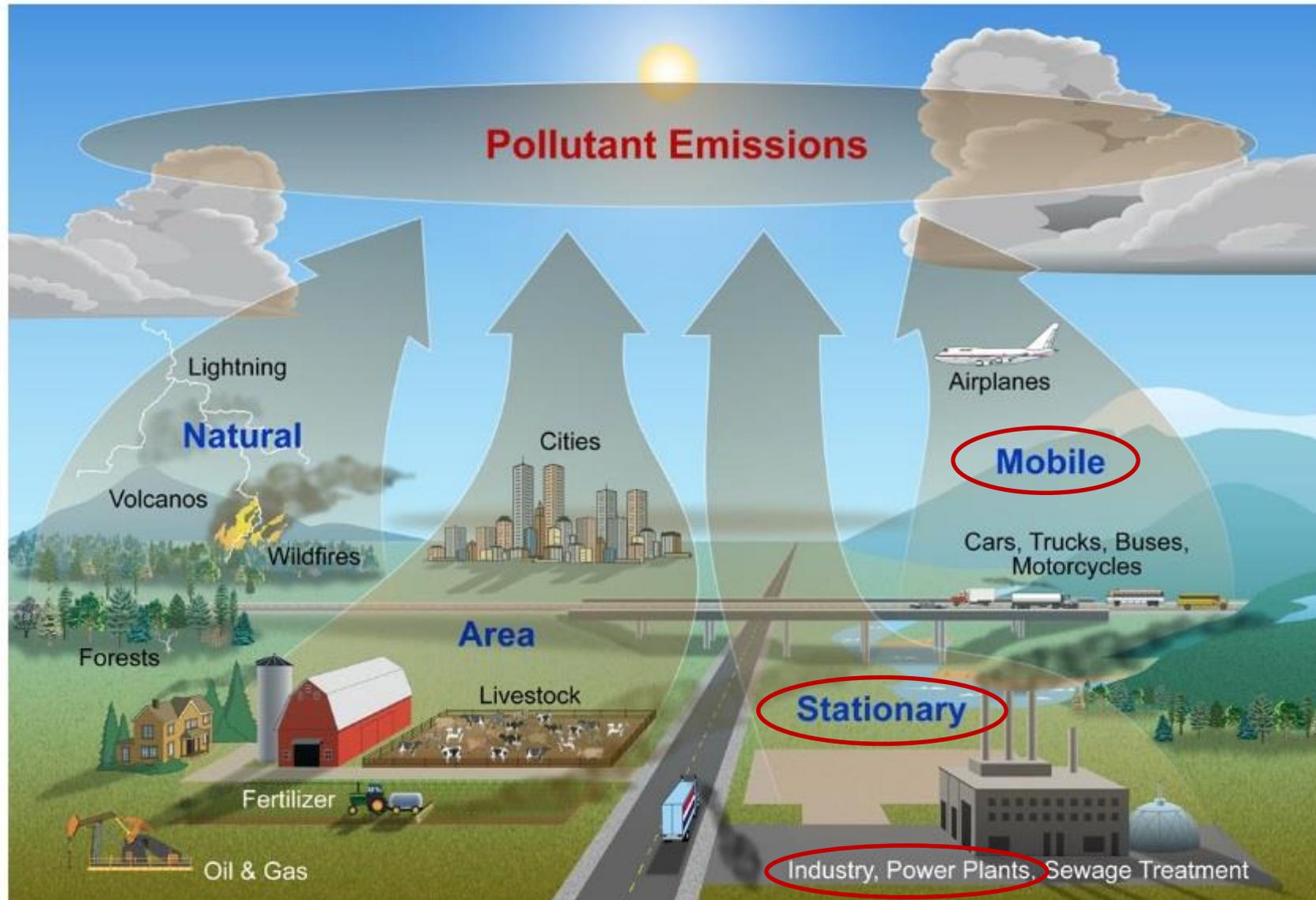
Pollutants Data...

Additional input file

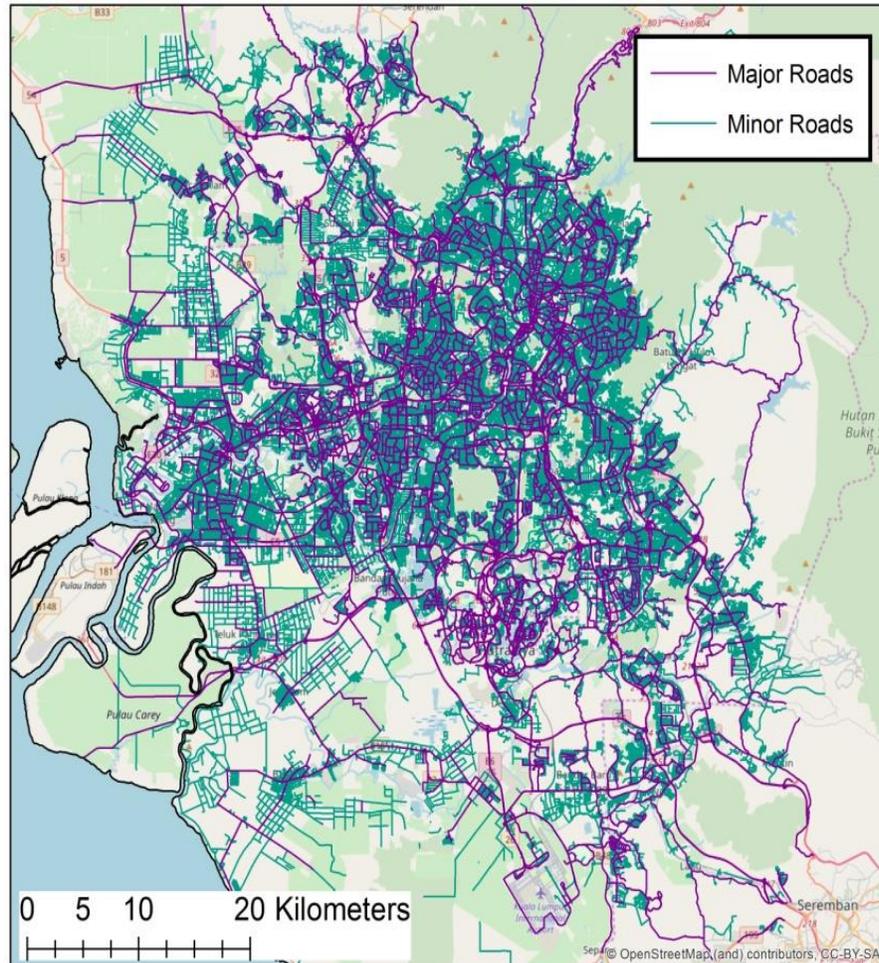
Browse... Edit

Enter the site name or other title (printed in output files) Min: Max:

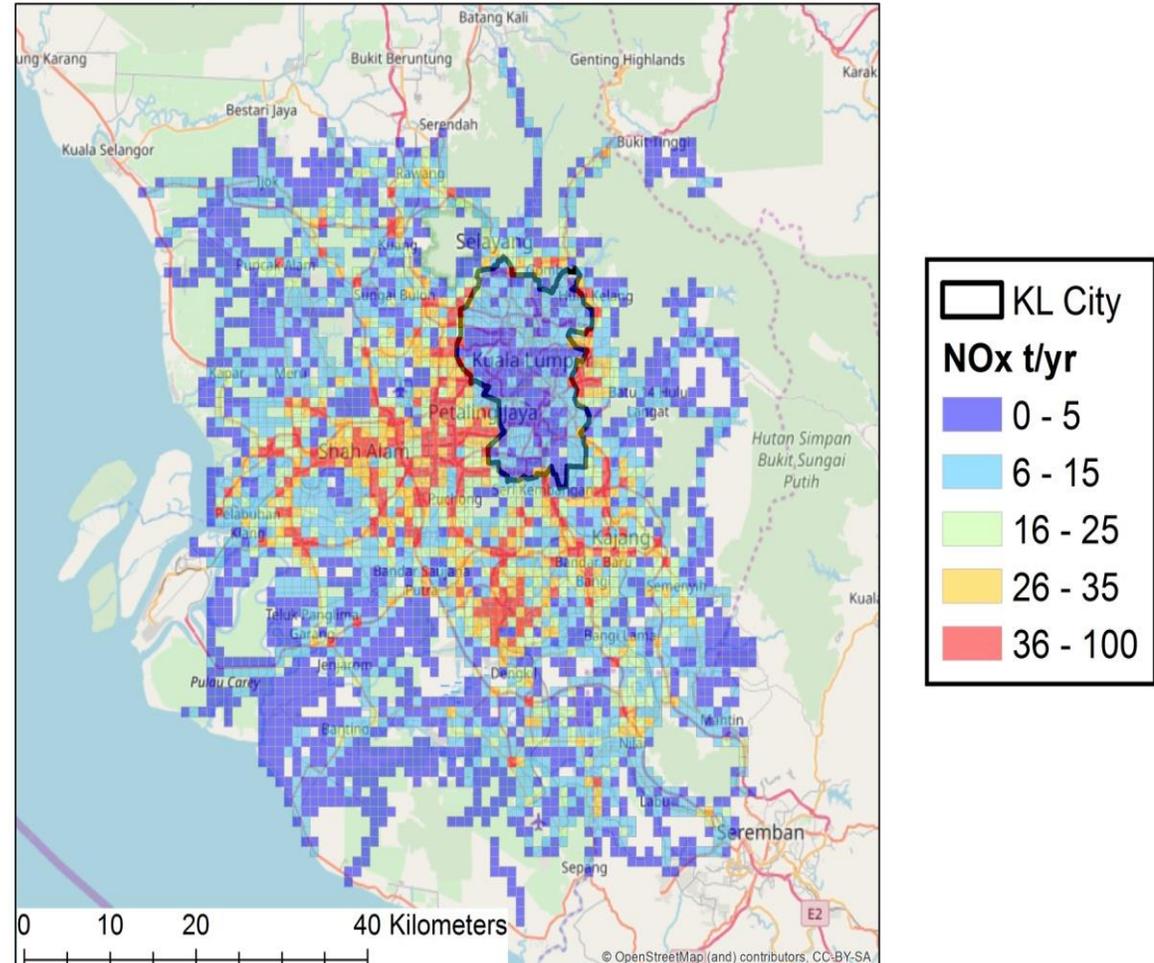
Preparation on Input Data



Preparation on Input Data : Traffic

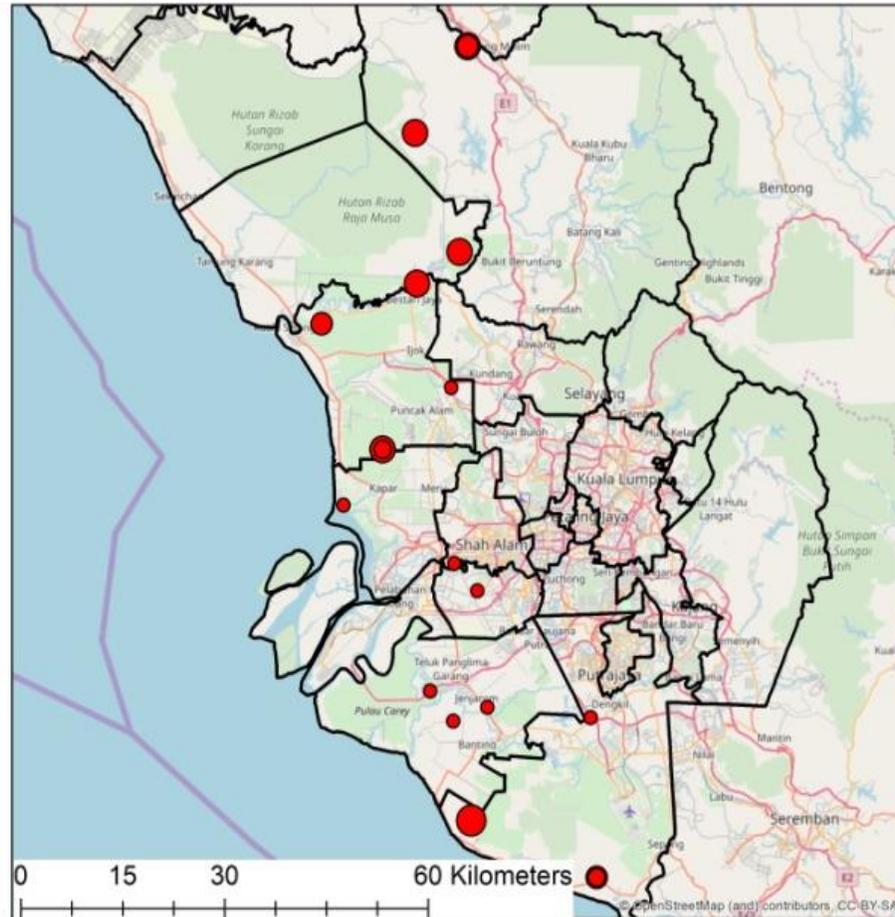


Major and Minor Roads



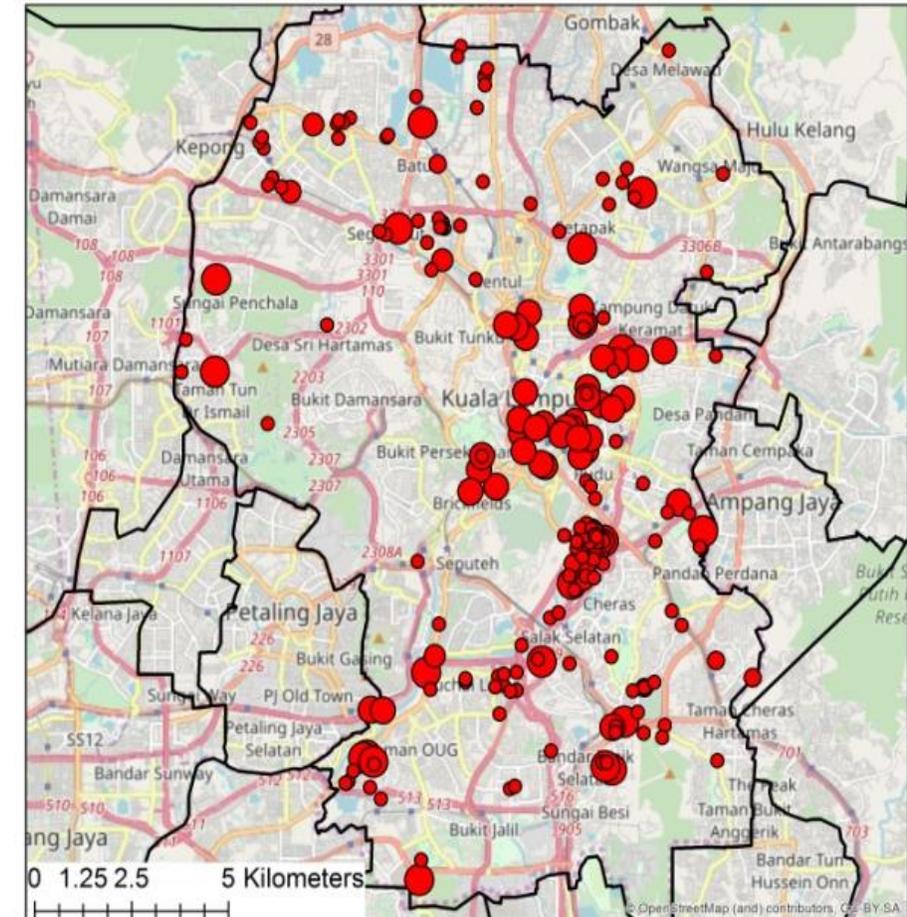
Gridded Roads (1km x 1km) for NOx emissions

Preparation on Input Data : Industrial



● Large industrial source locations indicating the relative PM₁₀ emission rate

© OpenStreetMap and contributors



● Small industrial source locations indicating the relative NO_x emission rate

© OpenStreetMap and contributors

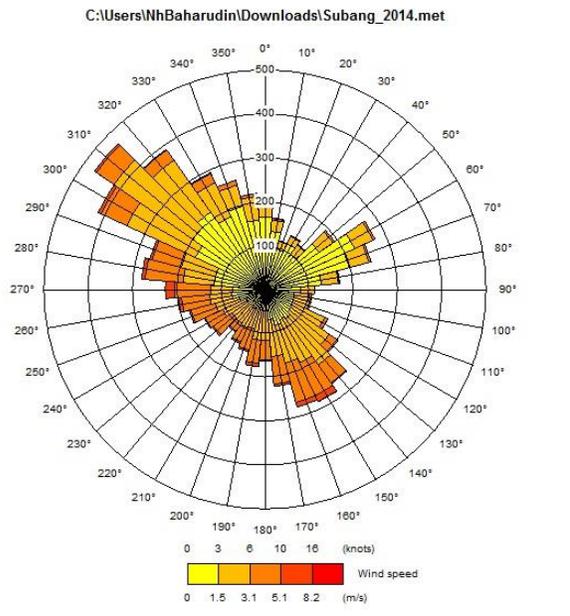
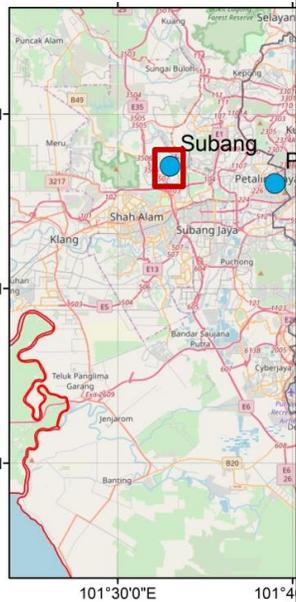
Preparation on Input Data



Meteorology

ADMS-Urban

Background



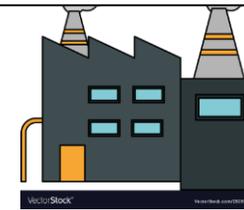
Annual average for 2014

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	Banting	0.62	60.11	13.24	23.15	3.25	21.25
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	Tanjung Malim	0.45	40.76	7.97	19.54	1.14	13.11

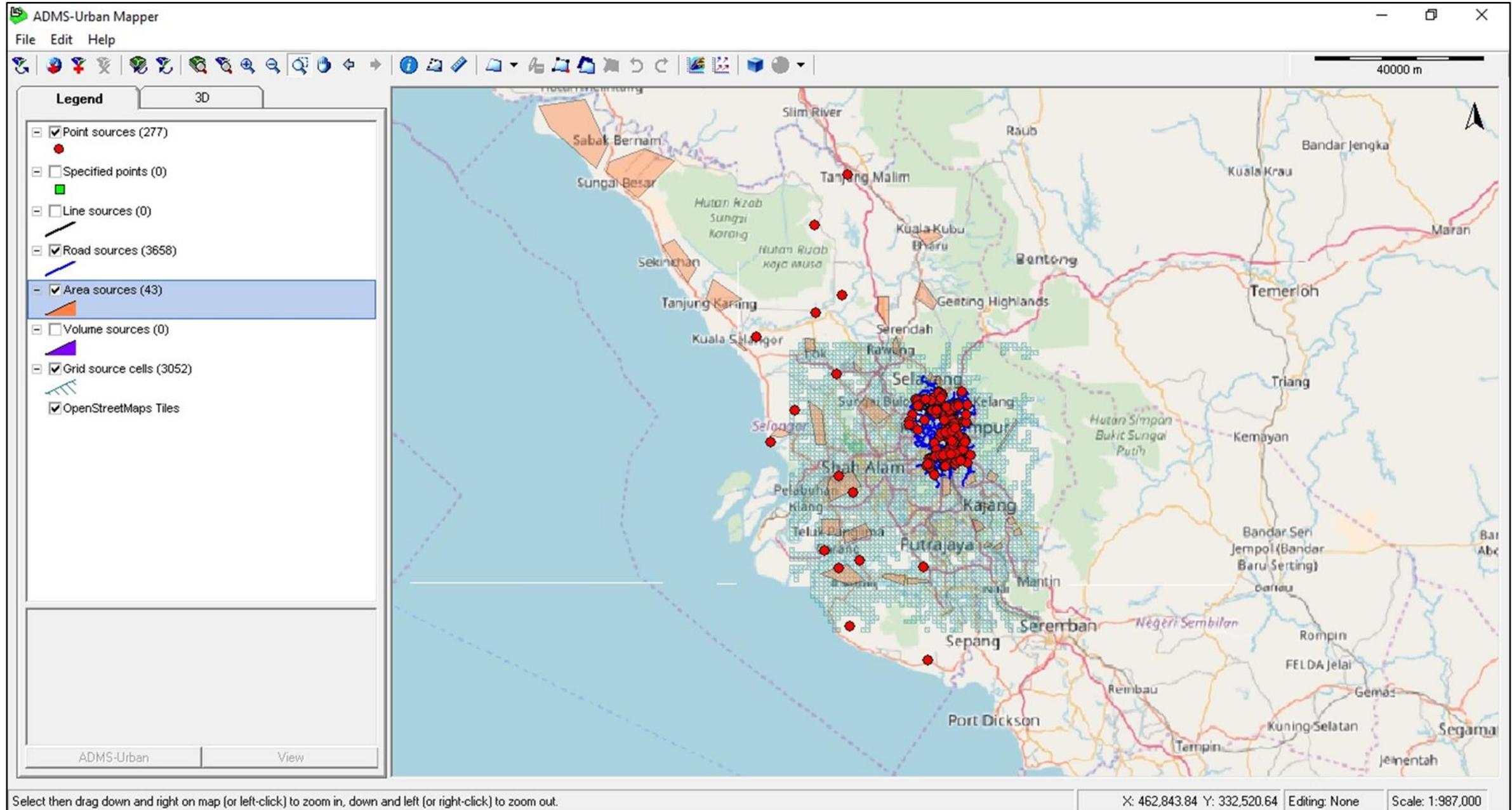
Sources

Traffic

Industrial



Methodology

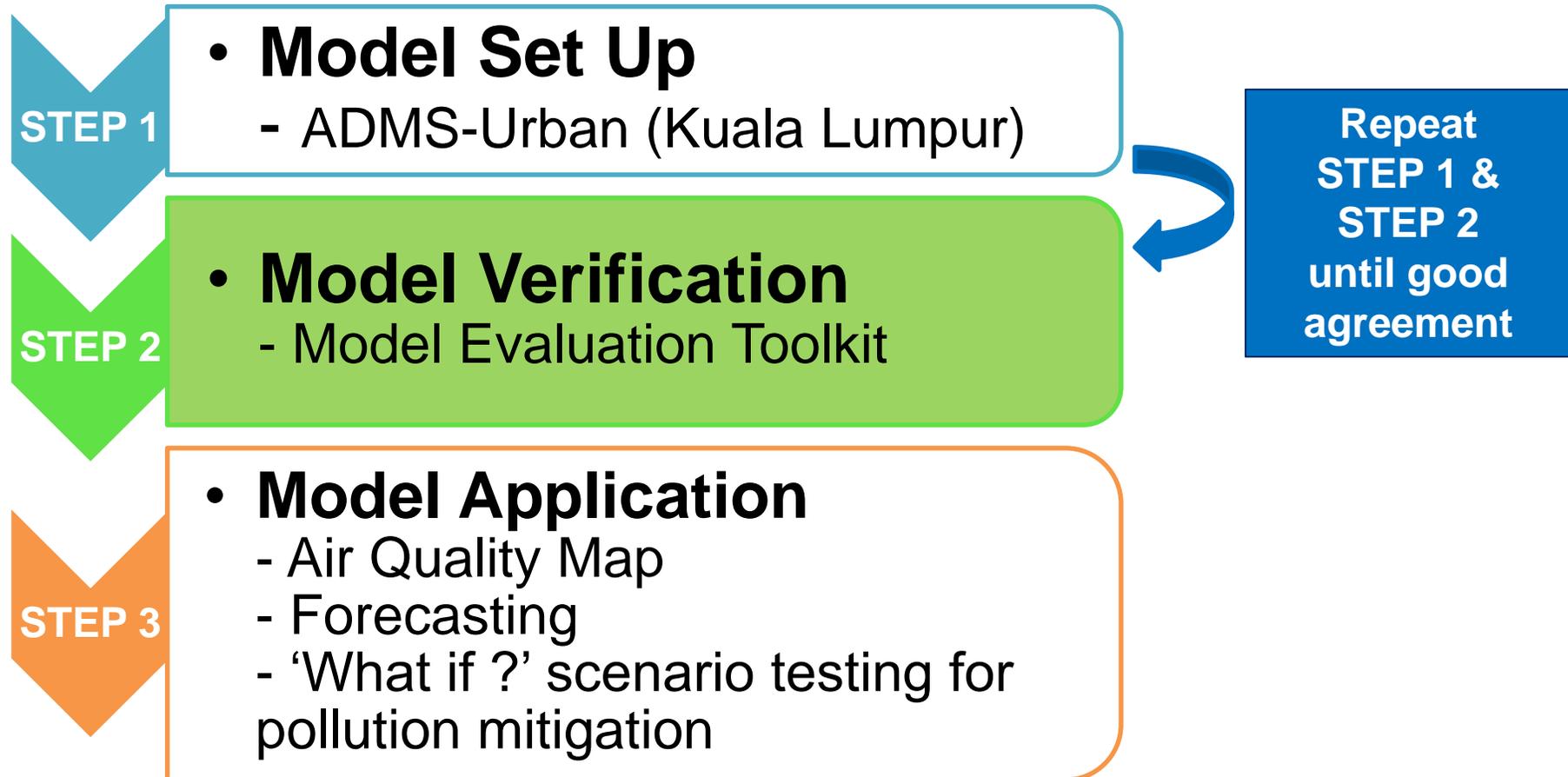


Select then drag down and right on map (or left-click) to zoom in, down and left (or right-click) to zoom out.

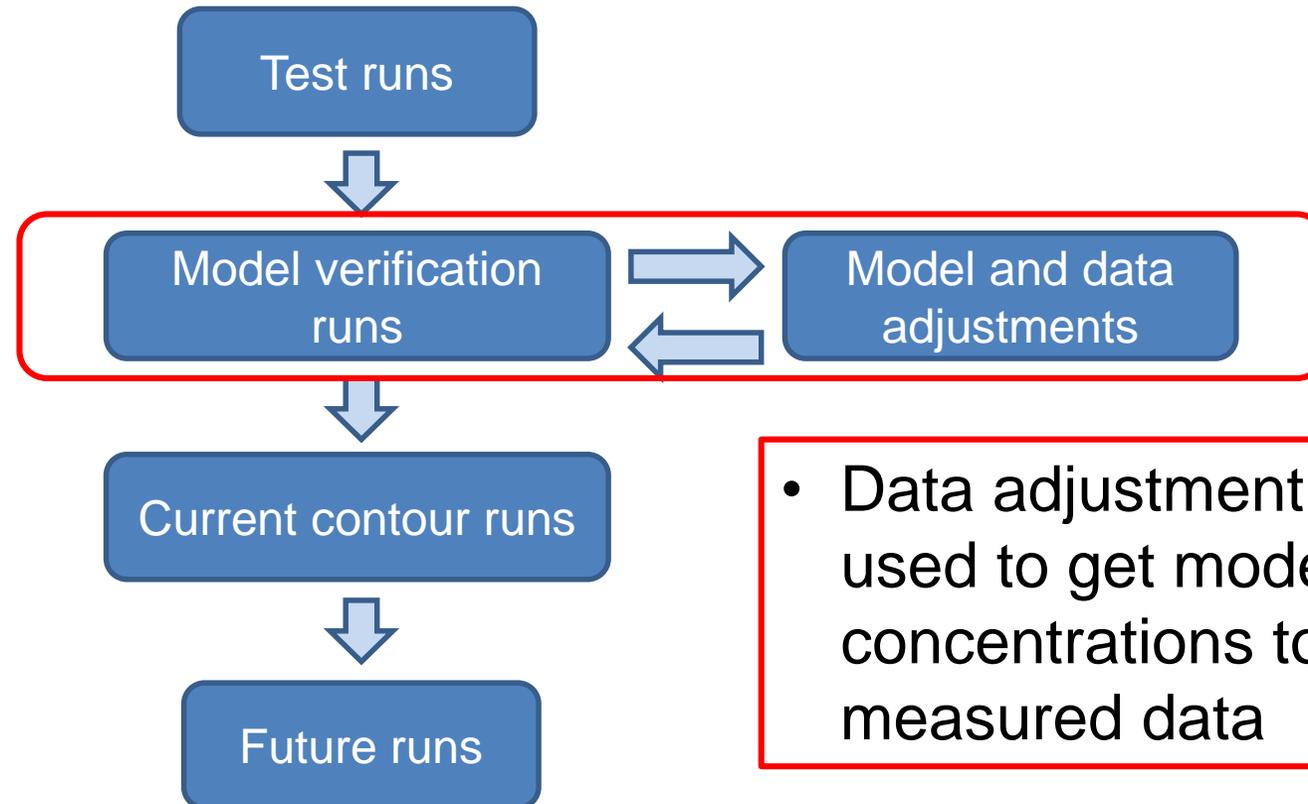
X: 462,843.84 Y: 332,520.64 Editing: None Scale: 1:987,000

Methodology

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



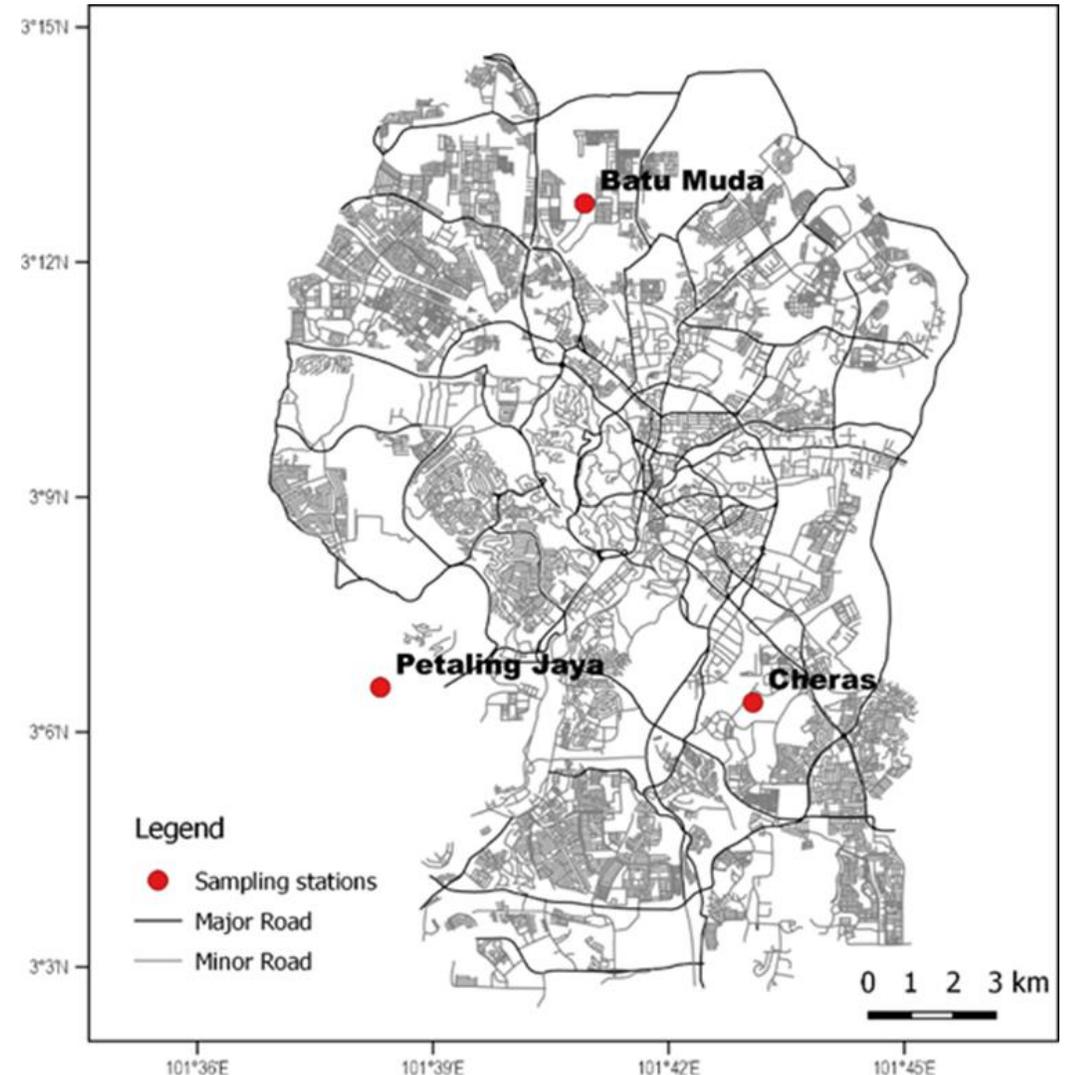
Model Verification



- Data adjustment are sometimes used to get modelled concentrations to fit measured data

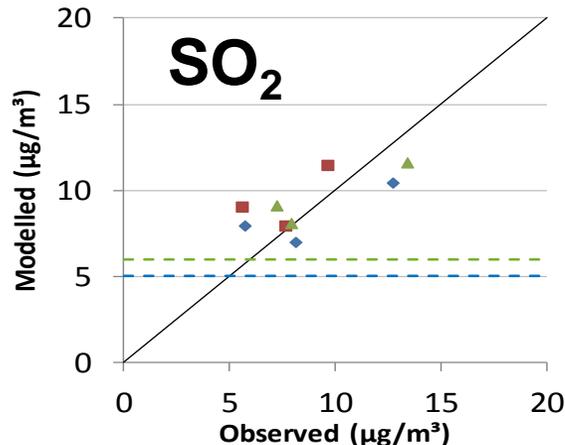
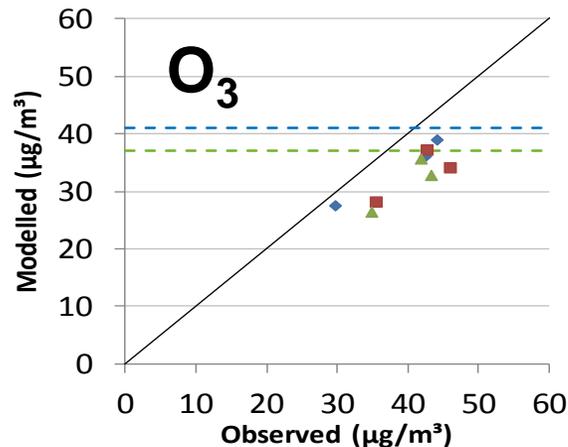
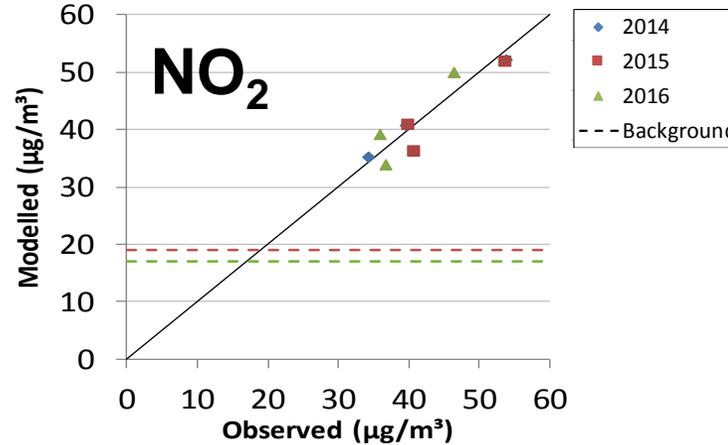
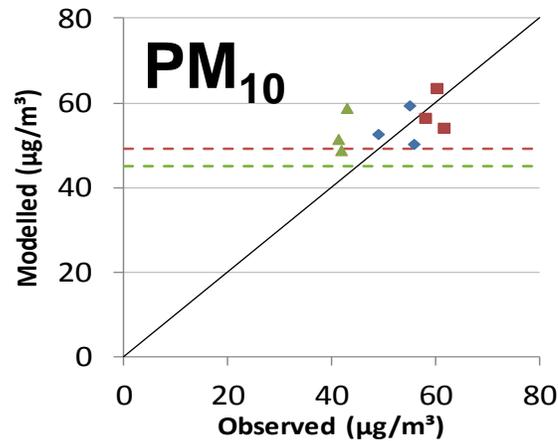
Model Verification

- 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)



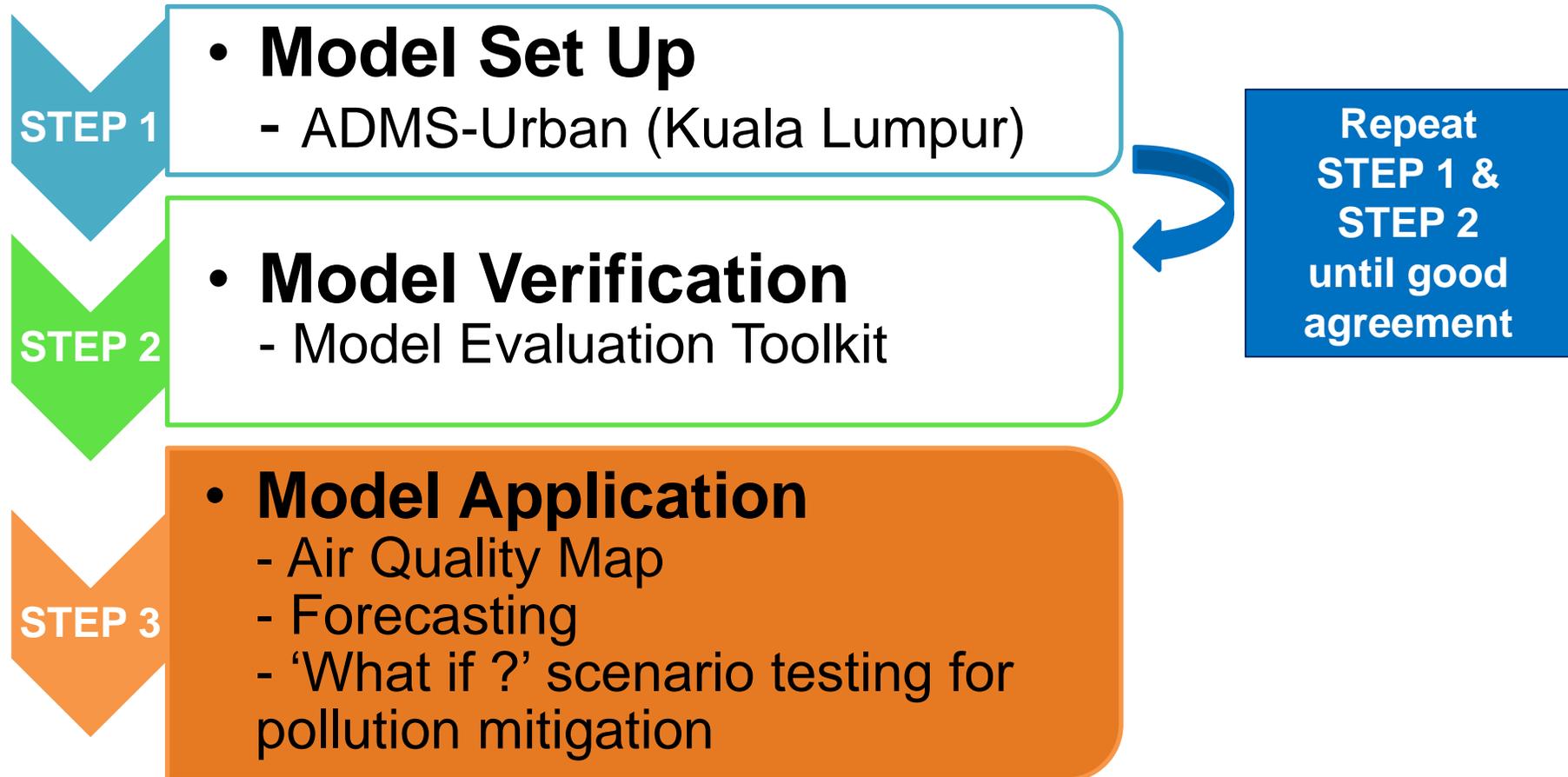
Statistics for hourly predictions

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

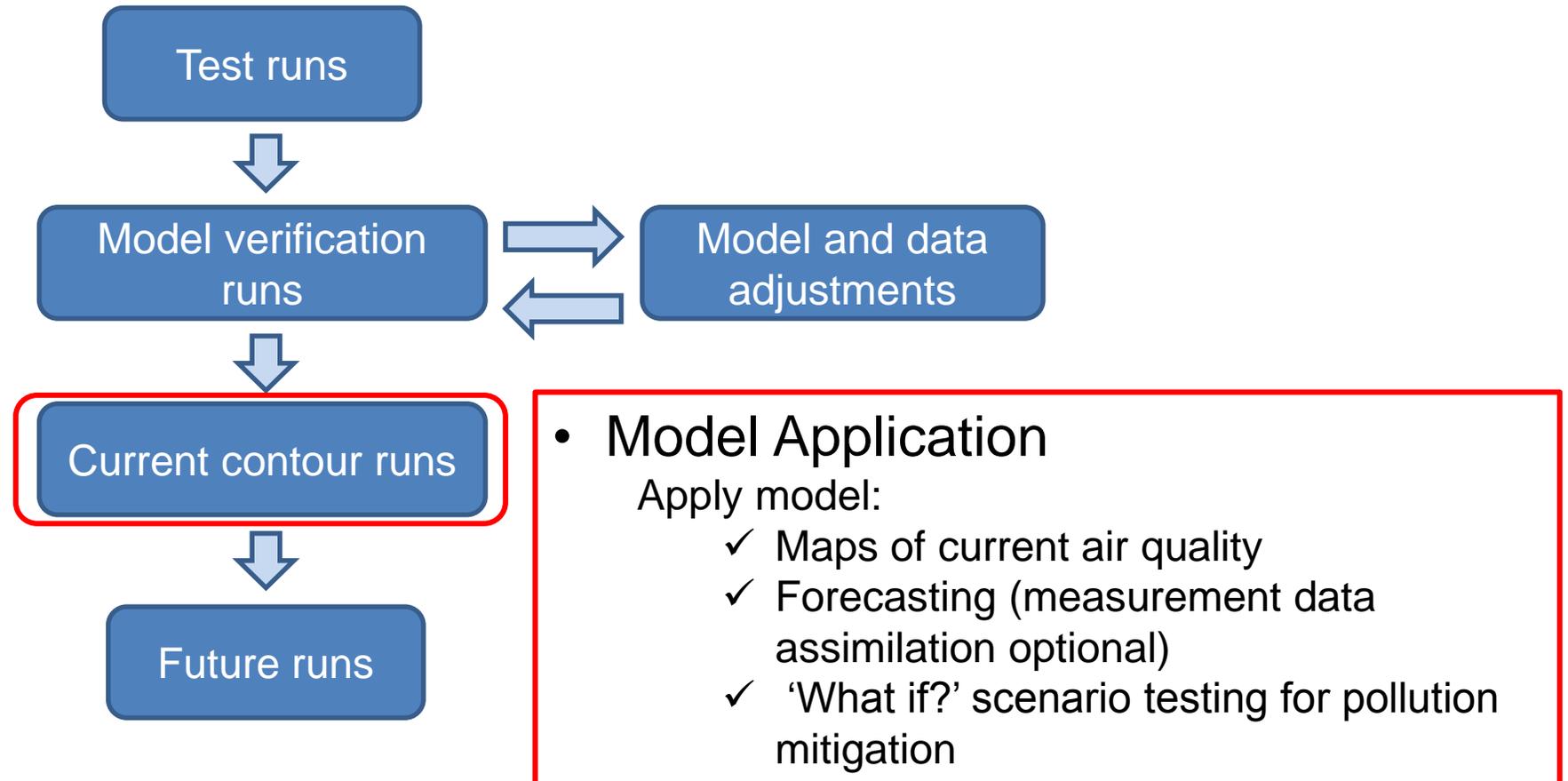
Fb = Fractional bias,
NMSE = normalised mean square error,
R = correlation

Methodology

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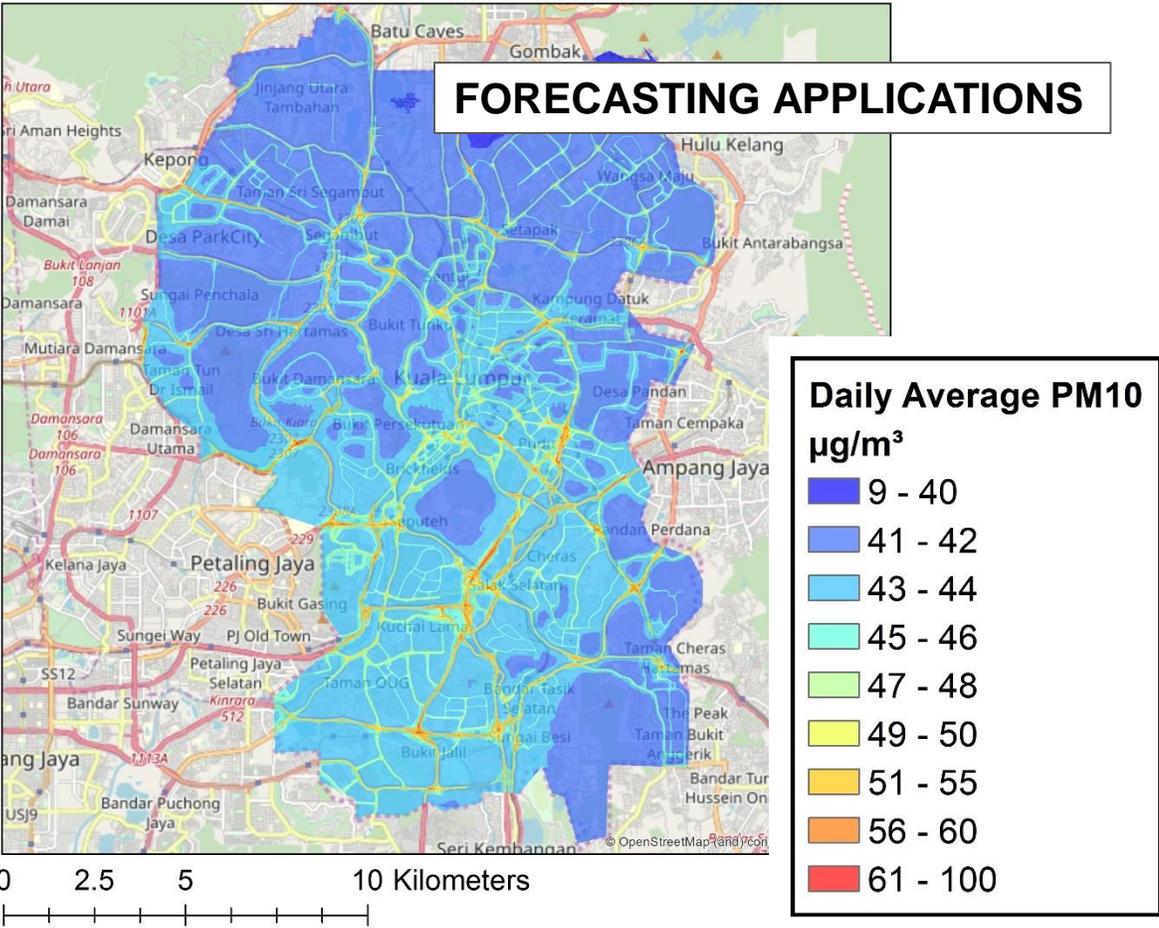


Model Verification

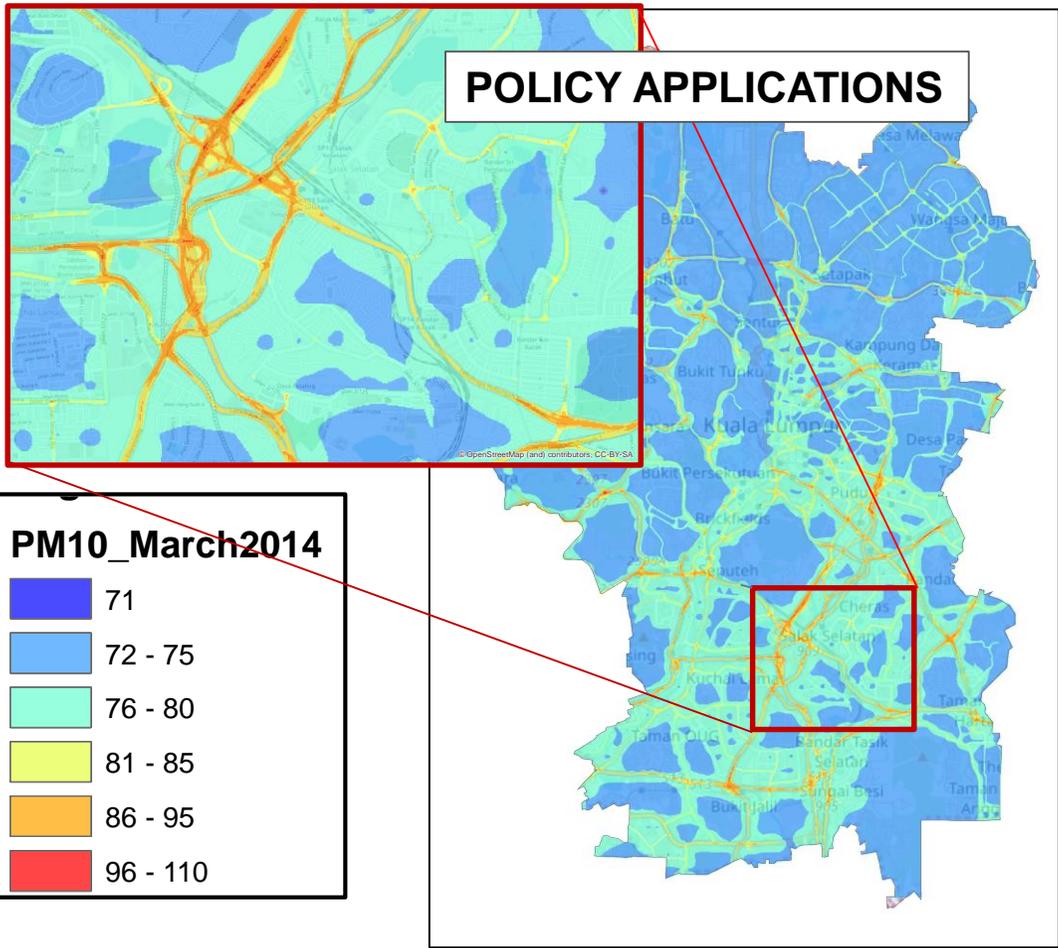


Air Quality Maps

- Daily PM10 concentrations



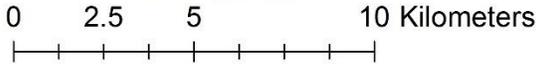
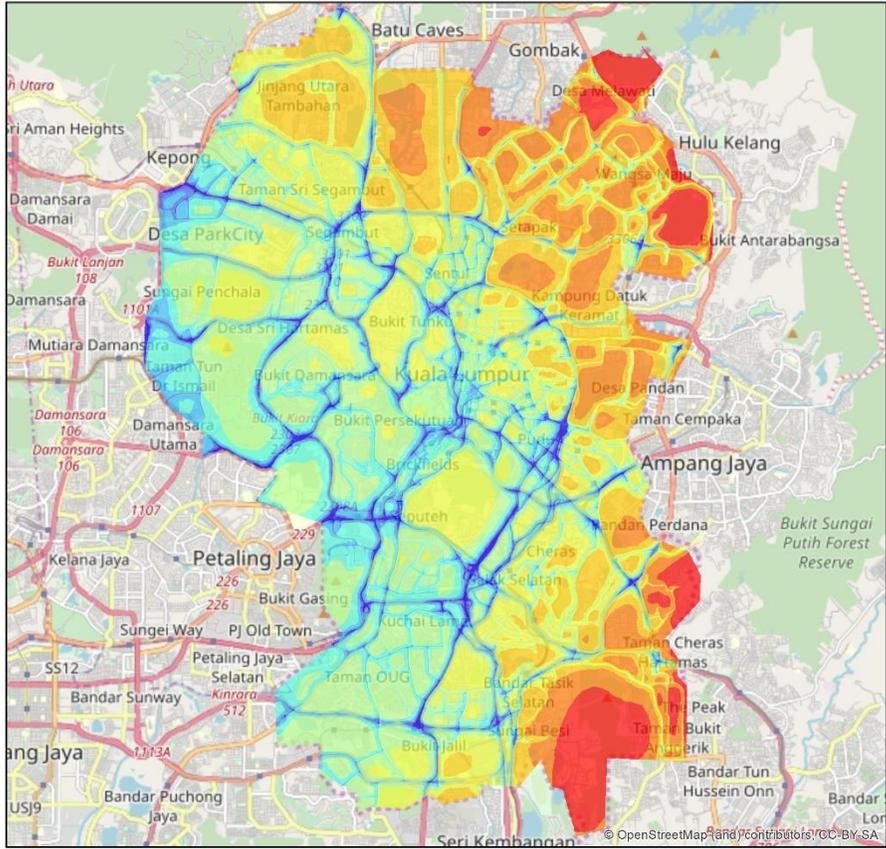
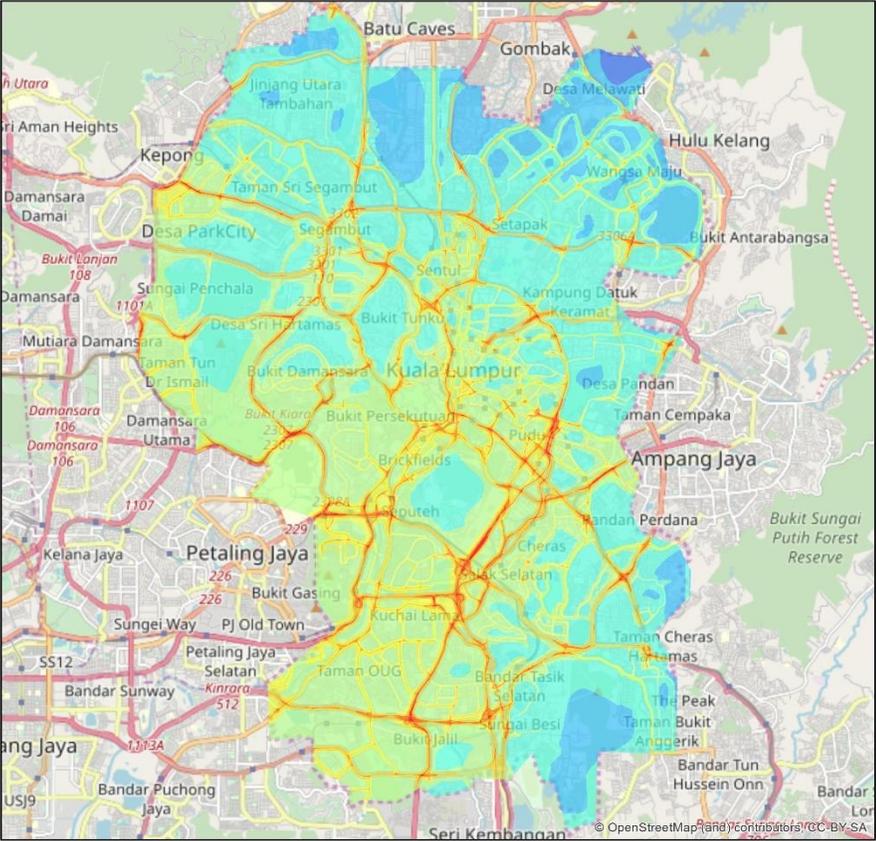
- March 2014 PM10 concentrations



Air Quality Maps

- Daily NO₂ concentrations

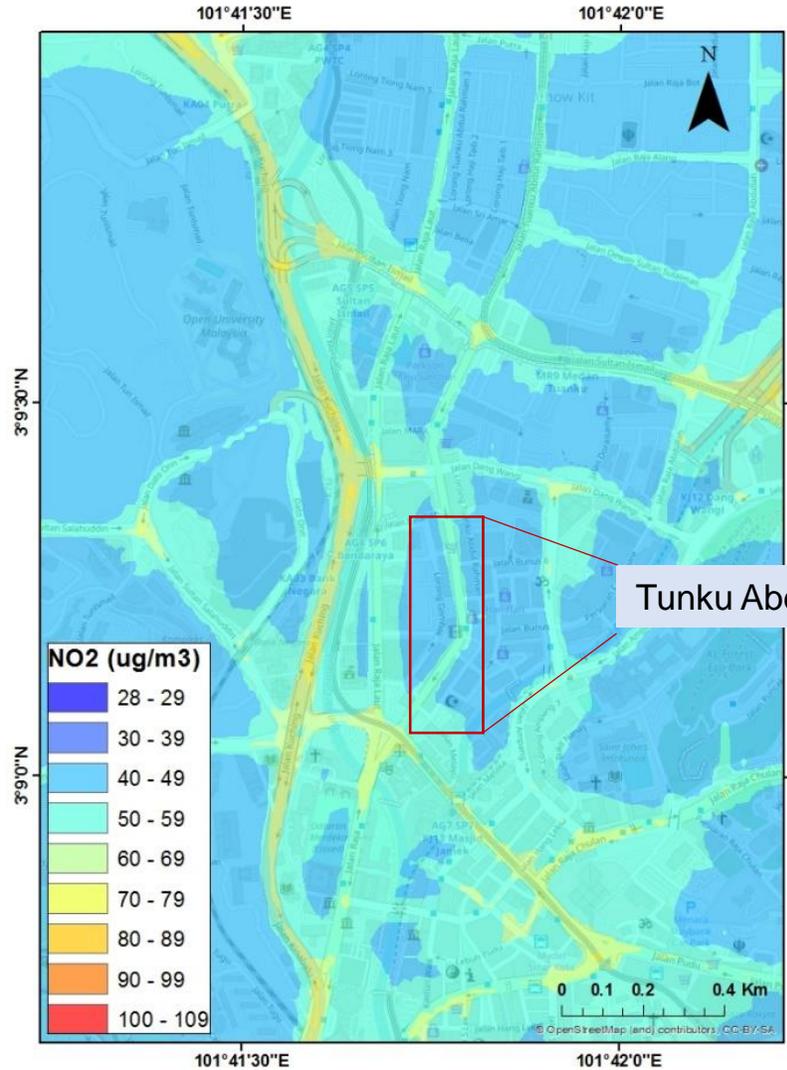
- Daily O₃ concentrations



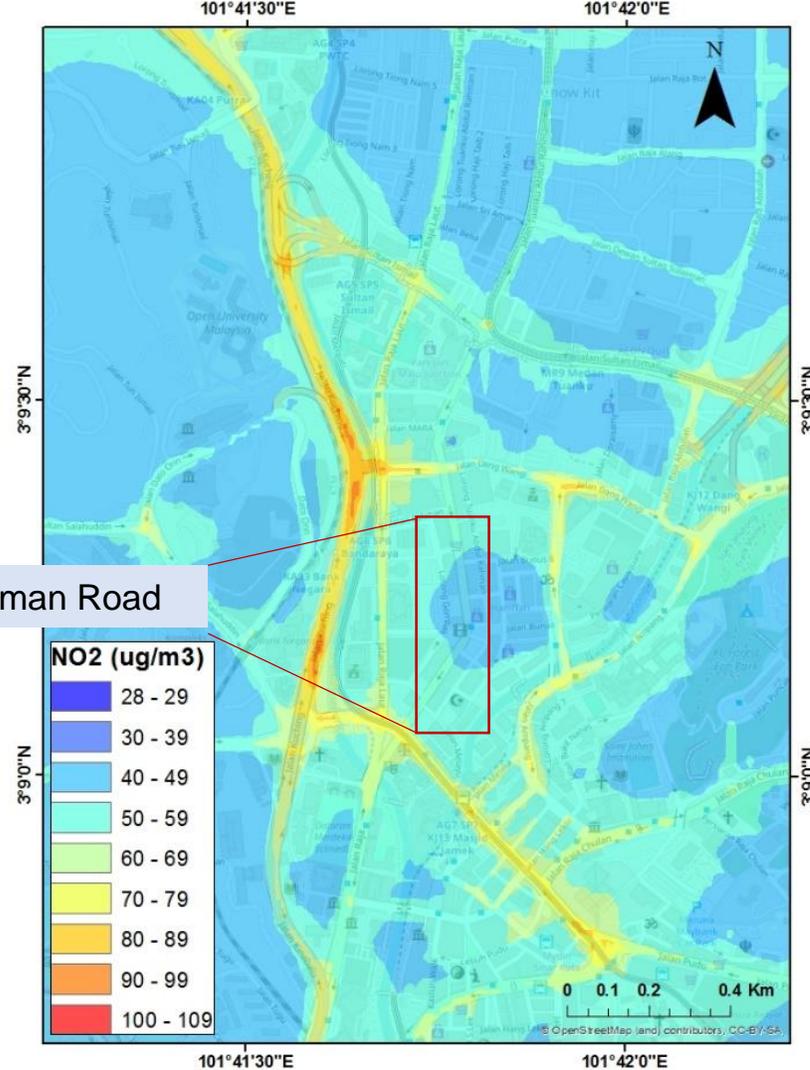
SCENARIO ROAD CLOSURE IN KUALA LUMPUR

Tunku Abdul Rahman Road

Before road closure



After road closure



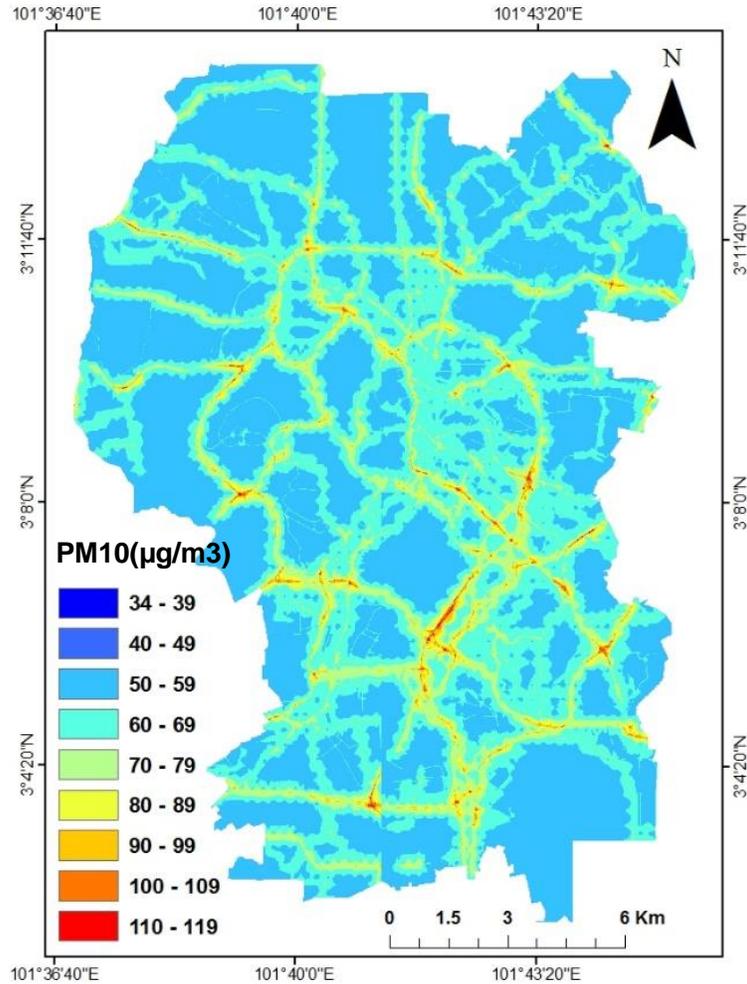
Tunku Abdul Rahman Road

Daily average concentrations of NO₂ (ug/m³) before and after Tunku Abdul Rahman road closure

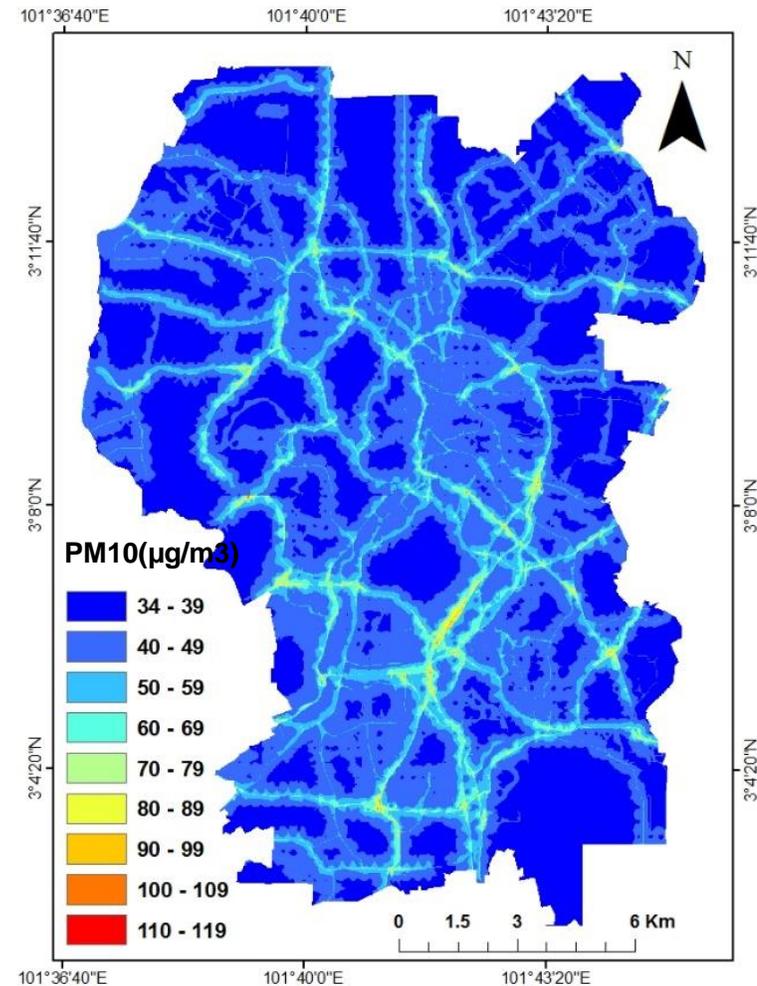
SCENARIO HAZE IN KUALA LUMPUR

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

Haze year (2015)



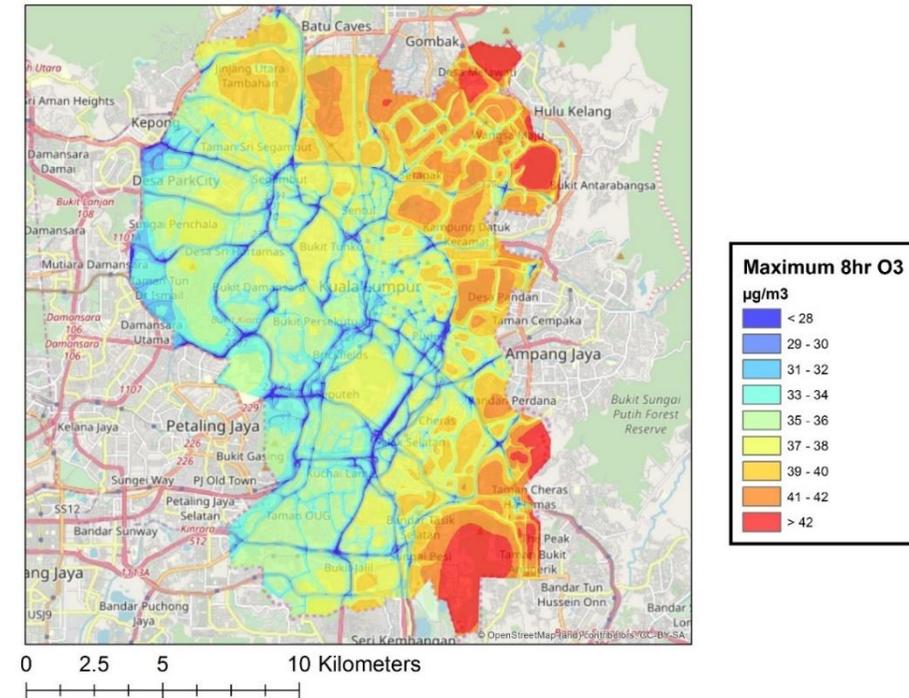
Non-Haze year (2016)



Daily average concentrations of PM10 ($\mu\text{g}/\text{m}^3$) for haze and non-haze year

Summary

- Model predictions of air quality pollutants compare generally **well** with measurements, particularly for **PM₁₀, O₃, NO_x & NO₂** (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

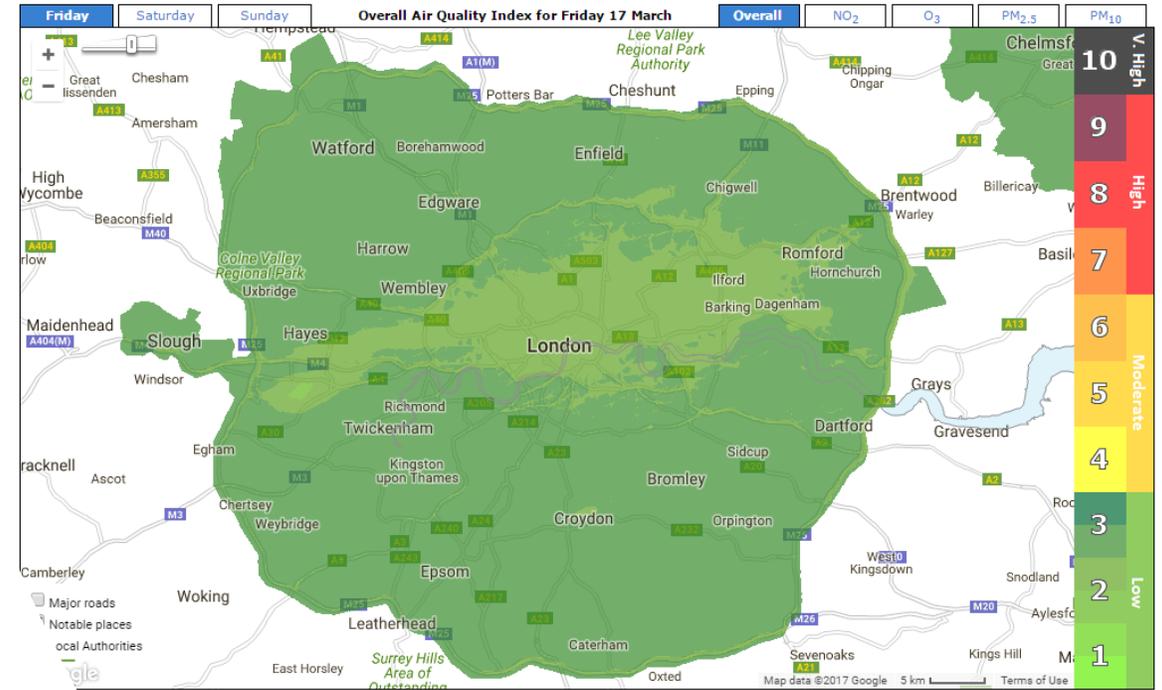
- Current model setup will be ready for provision of **detailed street-level air quality forecasts** – improving resilience to atmospheric hazards in Kuala Lumpur
- Future application:
 1. **air quality and health impact assessments** of proposed developments or urban planning
 2. **air pollution exposure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

airTEXT Air quality, UV, pollen and temperature forecasts for Greater London and the South East

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Maps show forecasts of expected air quality over the next three days, to enable you to plan ahead. Measurements of current air quality are available on LondonAir. See the health advice to learn more about how the expected pollution levels might affect your health. The maps are produced using CERC's world-leading ADMS-Urban air quality model.

Charged for your sign-up message at your standard text rate and then you will receive free text alerts for your area. Alternatively you can sign up online for free and choose to get alerts for your area by text, email or also download our free smartphone app.

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Thank you for your attention!

