Innovate UK MiGHT Malaysian Industry-Government Group for High Technology Newton-Ungku Omar Fund SCIENCE to ACTION

Disaster Resilient Cities: Forecasting Local Level Climate Extremes and Physical Hazards for Kuala Lumpur

Atmospheric Forecasting

Mr. Mark Jackson

Dr David Carruthers, Dr Jenny Stocker

Cambridge Environmental Research Consultants, UK

Workshop on Building Disaster and Climate Resilience in Cities, 16 October 2019, Kuala Lumpur

UNIVERSITY OF CAMBRIDGE · British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL · seadpri southeast asia disaster prevention research initiative · UNIVERSITY OF MALAYA KUALA LUMPUR · MET Malaysia · JMG · Jabatan Alam Sekitar Malaysia · UCL · CERC · UKM PAKARUNDING · CORE Expert Systems · GMT Geomapping Technology Sdn Bhd (593061-U) · JBA consulting · Cuesta · GEOLOGICAL SOCIETY OF MALAYSIA · Asian Network on Climate Science and Technology (ANCST)

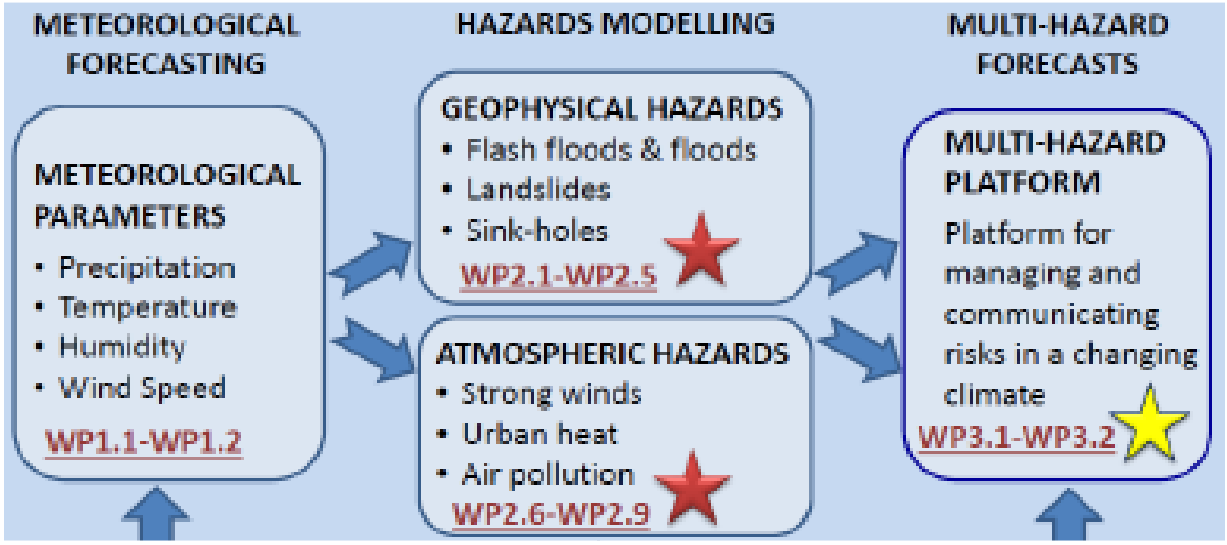
Summary

- NUOF Hazard Forecasting project
  - Overview
  - Multi-hazard platform and atmospheric forecasts
- Short-term urban heat forecasts
  - Applying and verifying the model for Kuala Lumpur
- Short-term air quality forecasts
  - Applying and verifying the model for Kuala Lumpur
  - Recent haze episode and Indonesian fires

Innovate UK MiGHT Malaysian Industry-Government Group for High Technology Newton-Ungku Omar Fund

An international city-scale project for a tropical environment:

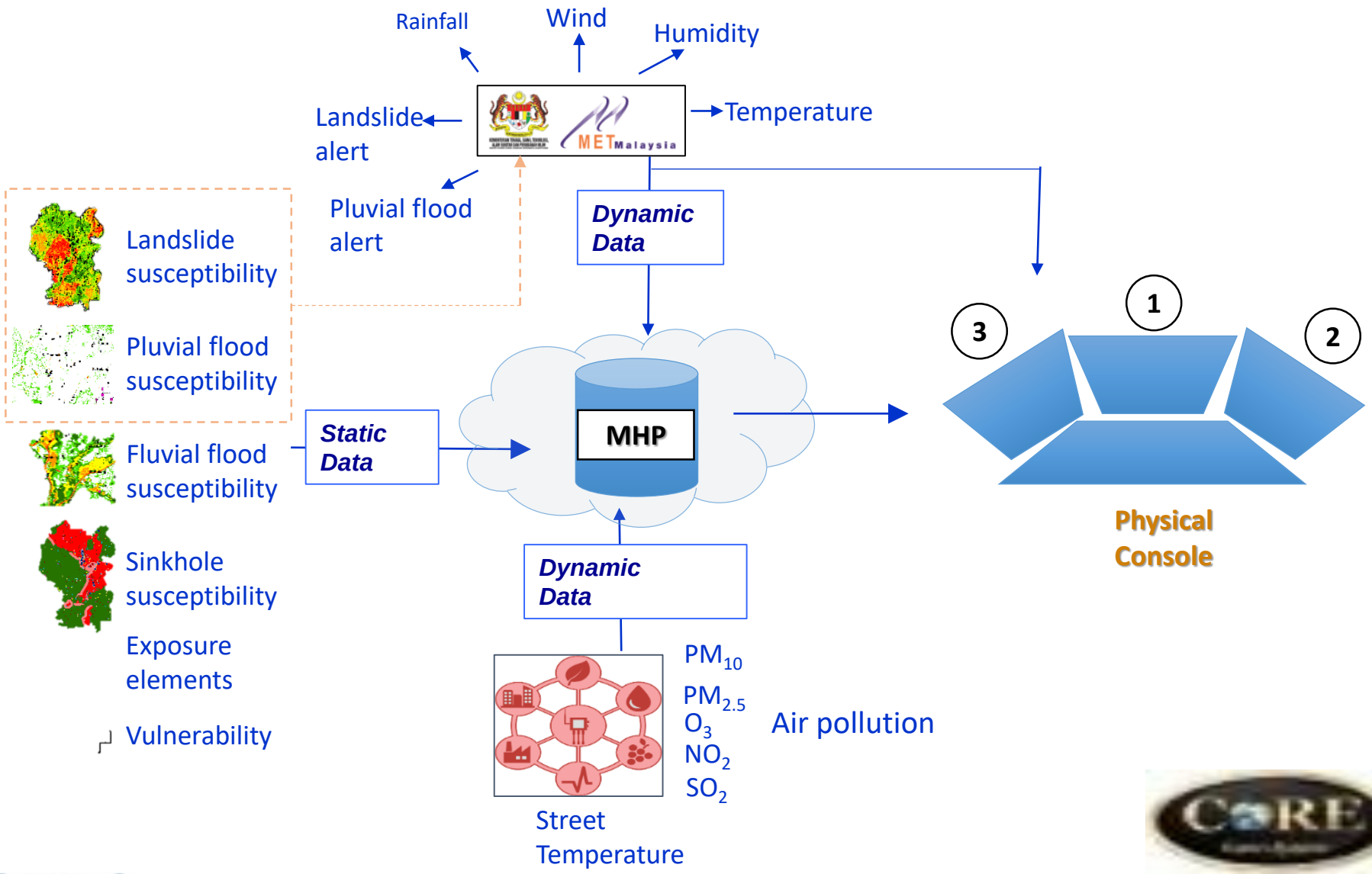
Disaster Resilient Cities: Forecasting Local Level Climate Extremes and Physical Hazards for Kuala Lumpur



MULTIHAZARD PLATFORM

Dynamic & Static Data

Work is on-going



CERC

Short-term urban heat forecasts

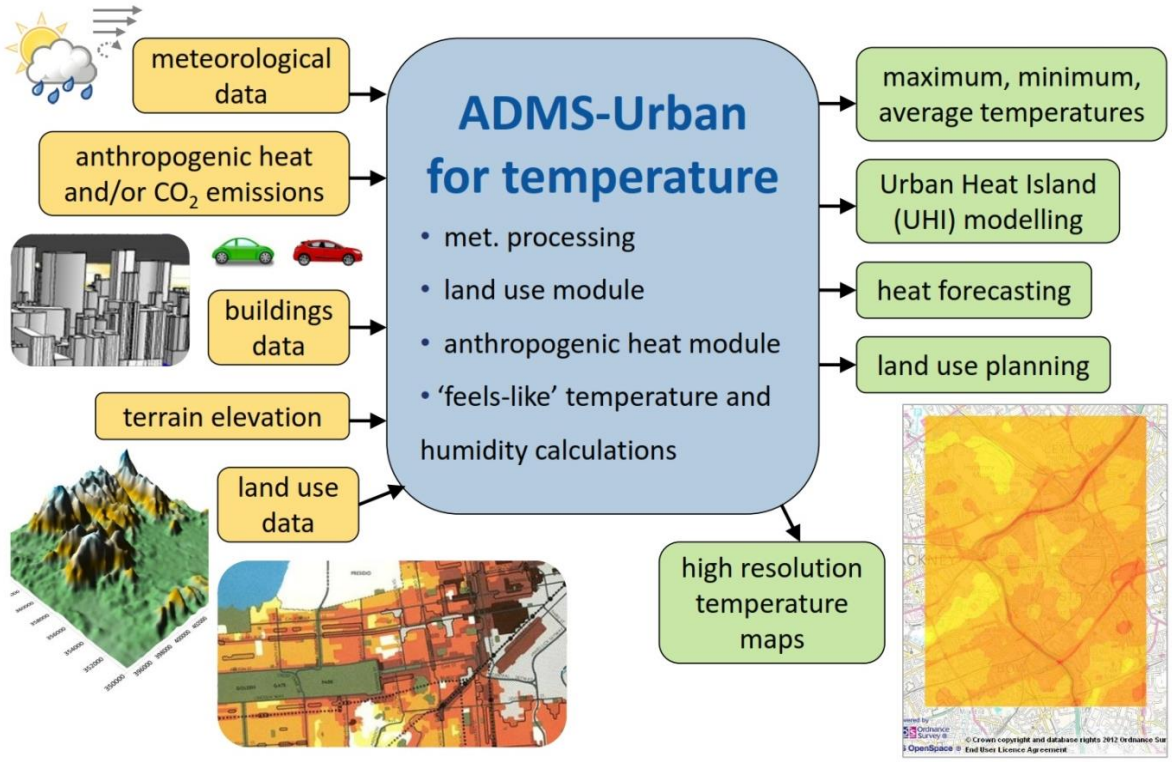
CERC'S ADMS-URBAN MODEL

Temperature and humidity modelling software

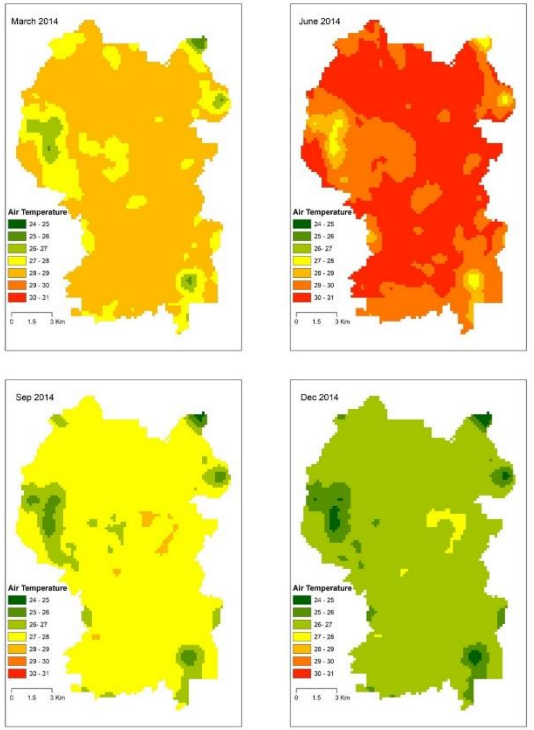
Preliminary Findings

The 'Disaster Resilient Cities' project team have

- Applied and verified ADMS-Urban for a tropical city: Kuala Lumpur
- Set up a short-term high resolution temperature forecast system



Predicted seasonal variation



Data provided by DOE, DBKL, Energy Commission, Ministry of Works, Met Malaysia

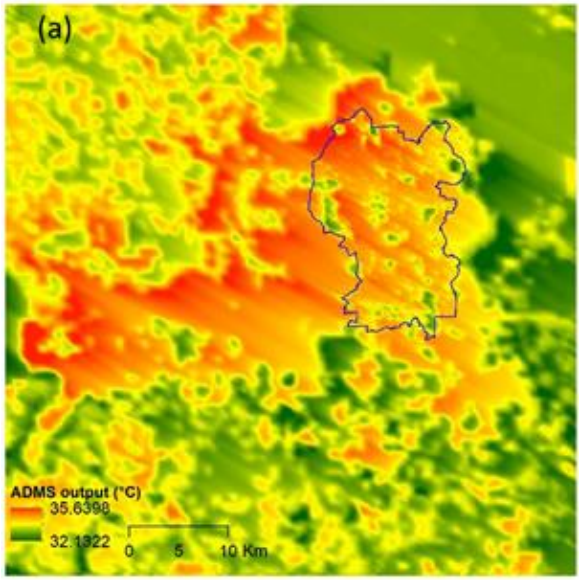
CERC UCL UKM PAKARUNDING MET Malaysia

VERIFICATION OF ADMS-URBAN TEMPERATURES

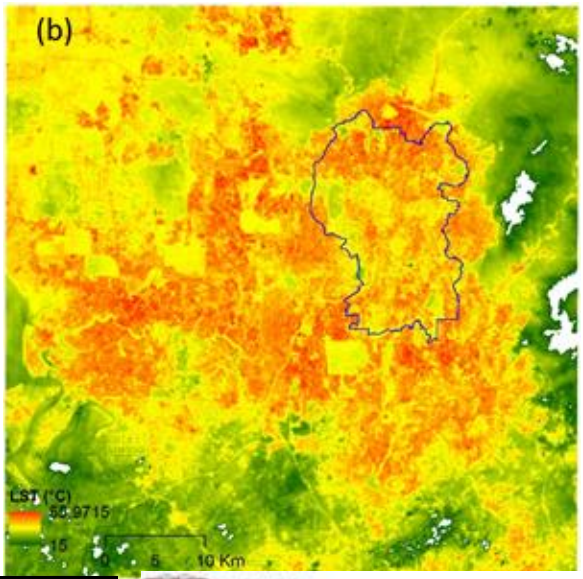
Preliminary Findings

Spatial pattern 12:00 on 30 May 2015

Modelled



Derived from satellite (Landsat)



Wang, K., *et al*
Geoscience Letters, 2019
DOI:10.1186/s40562-019-0134-2

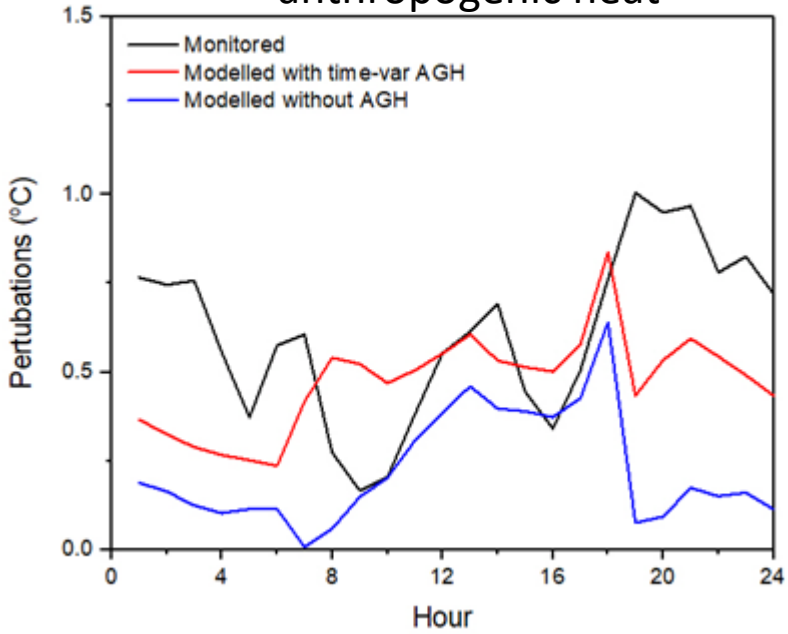
CERC UCL UKM PAKARUNDING

Diurnal variation

Measured

Modelled with anthropogenic heat

Modelled without anthropogenic heat



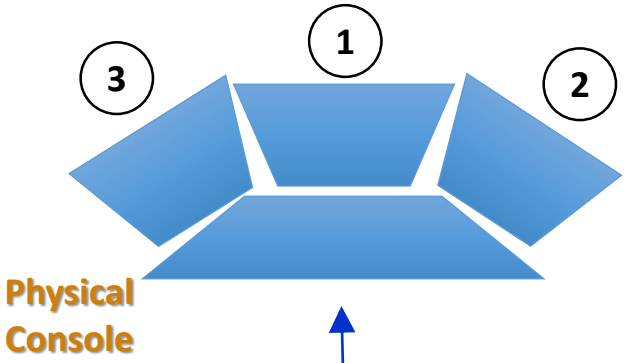
For, Petaling Jaya,

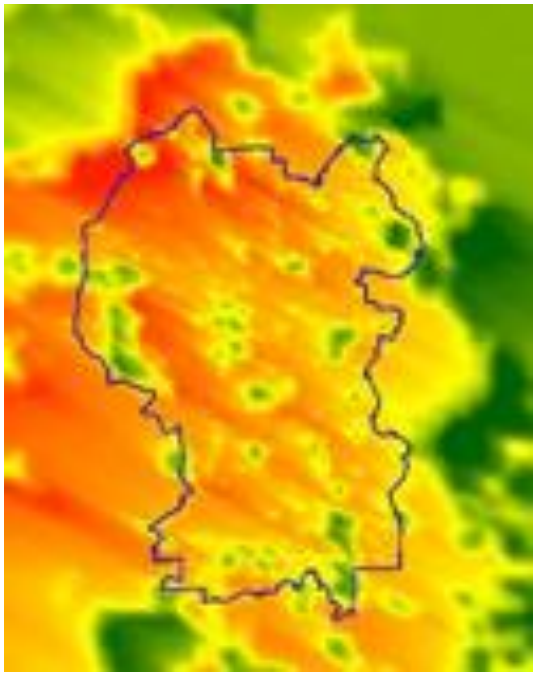
Uses measured meteorology (Met Malaysia) as upwind input and to compare with predictions

PRODUCTION OF ATMOSPHERIC FORECASTS

Detailed Temperature Short-Term Forecast

Work is on-going





2-day forecast temperature maps

ADMS LOCAL TEMPERATURE FORECAST MODEL

By UKMP, CERC, UCL, Met Malaysia

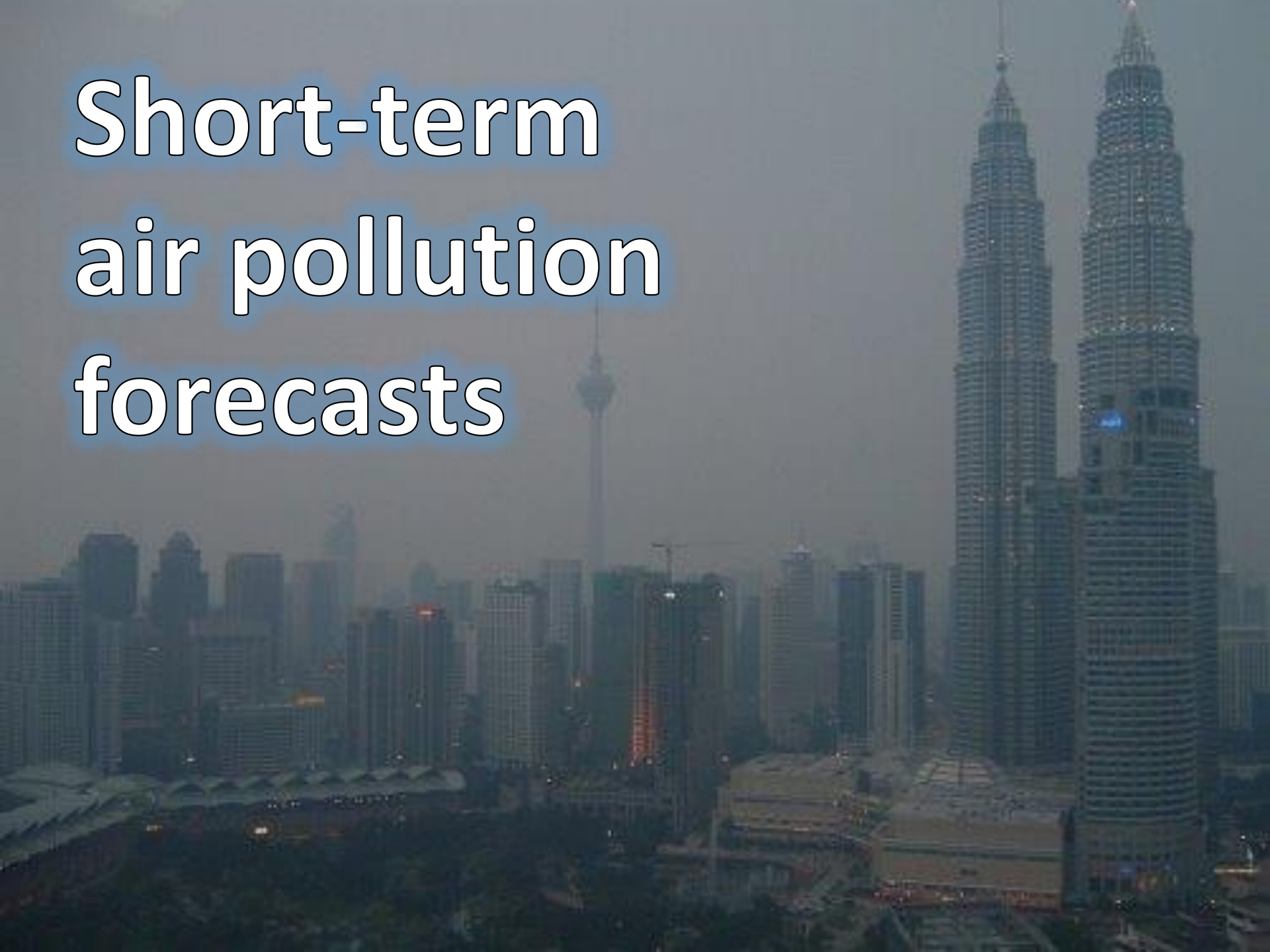
FORECAST METEOROLOGICAL MODEL (WRF)

By Met Malaysia

UKMO FORECAST METEOROLOGICAL MODEL (UM)

By UK Met Office

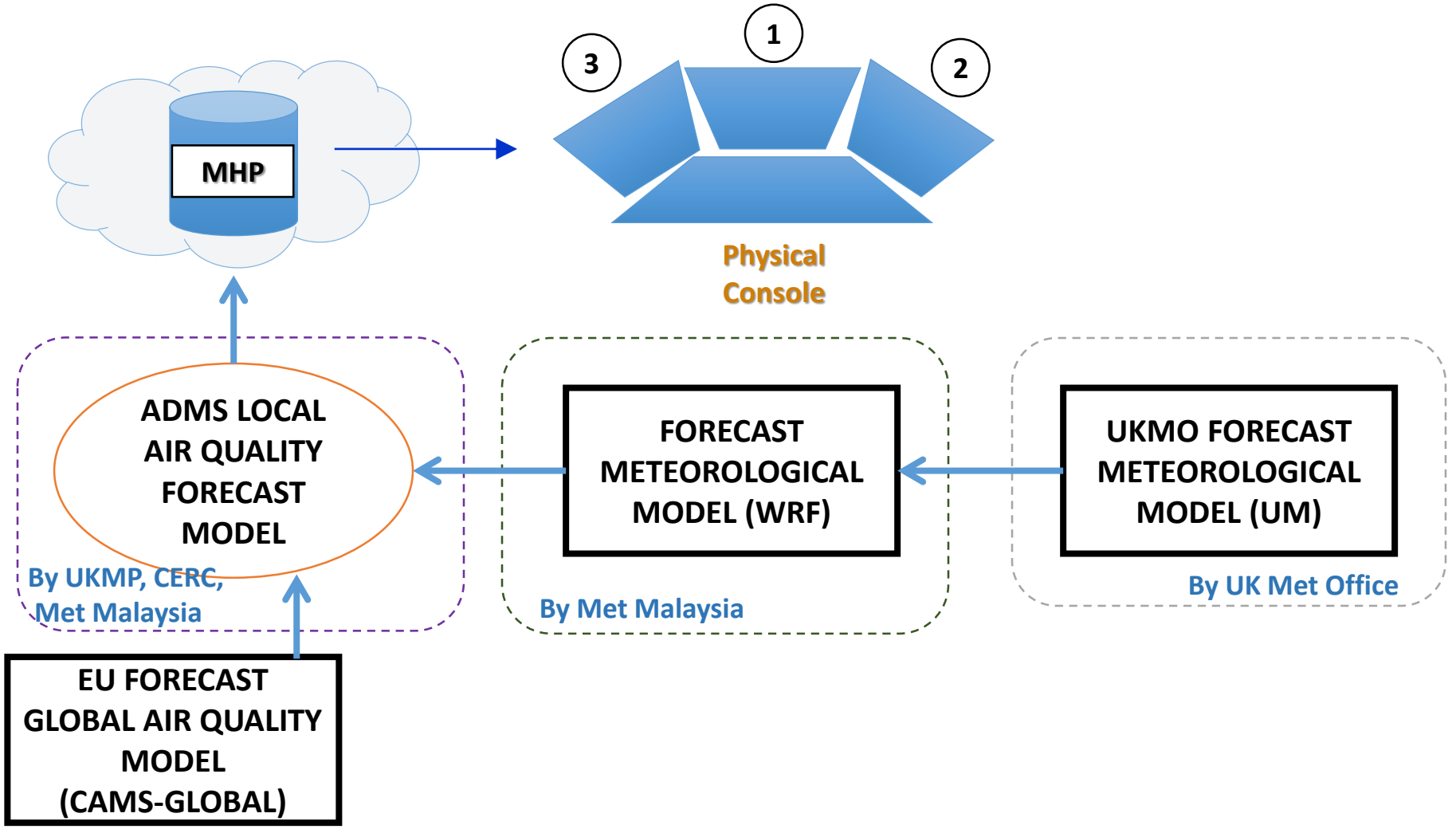
CERC UCL UKM PAKARUNDING rc MET Malaysia CoRE


Short-term
air pollution
forecasts

PRODUCTION OF ATMOSPHERIC FORECASTS

Air Quality Short-Term Forecast

Work is on-going



CERC UKM PAKARUNDING MET Malaysia CoRE

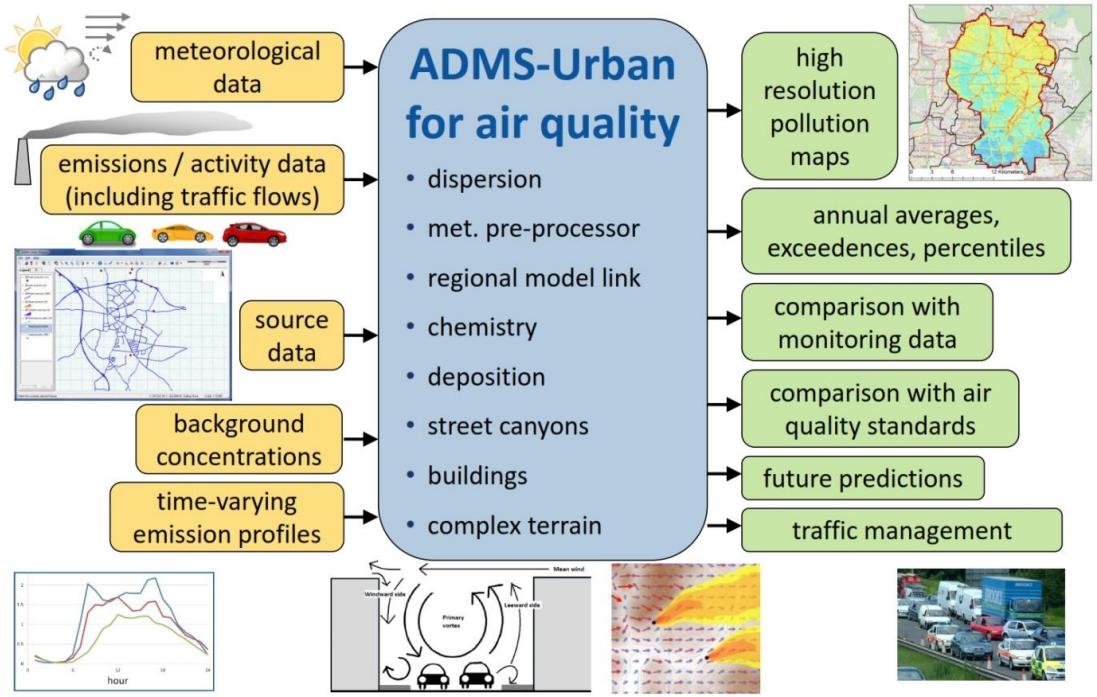
CERC'S ADMS-URBAN MODEL

World-leading atmospheric dispersion software

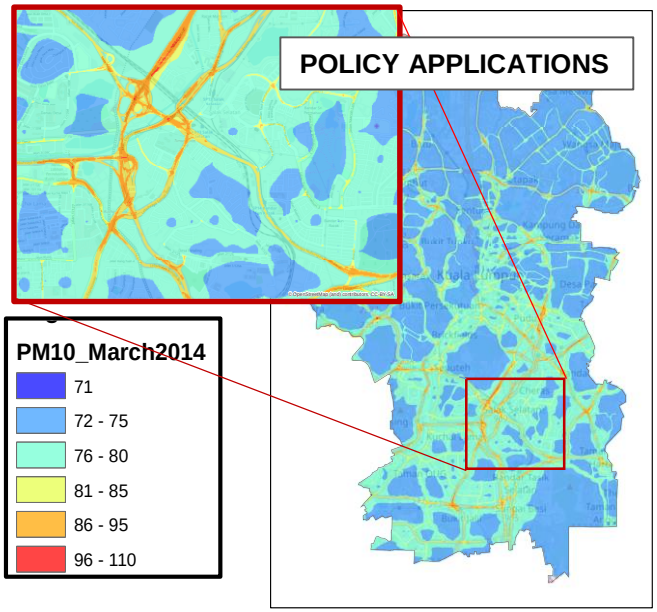
Preliminary Findings

The 'Disaster Resilient Cities' project team have

- Applied and verified ADMS-Urban for a tropical city: Kuala Lumpur
- Assessed policy scenarios such as road closure and regional haze
- Set up a short-term air quality forecast system



March 2014 PM_{10} concentrations



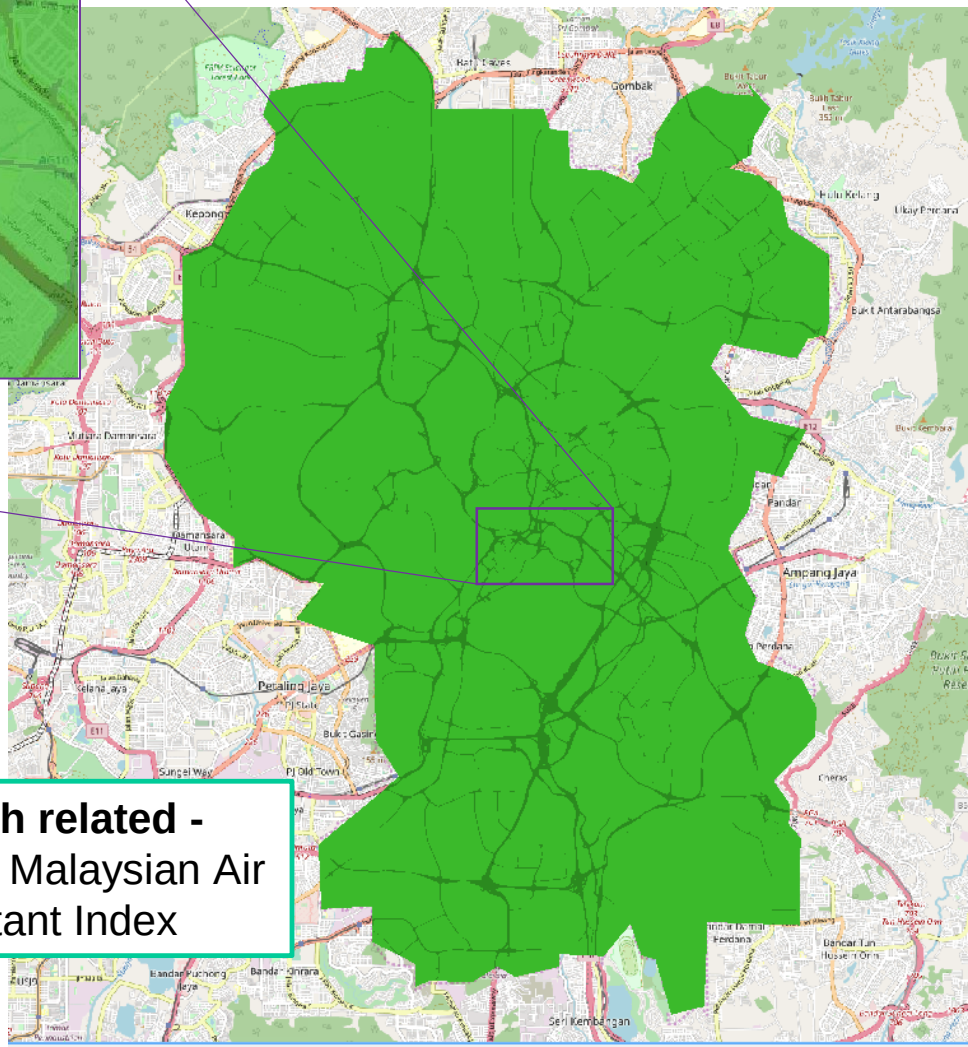
Data provided by DOE, DBKL, Ministry of Works, Met Malaysia

Pollution maps –at street-scale resolution (~ 10 m near roads, ~ 50 m urban background)

2 day forecasts issued by 04:00 Malaysian time

PM10, PM2.5, NO2, O3, SO2

Work is on-going

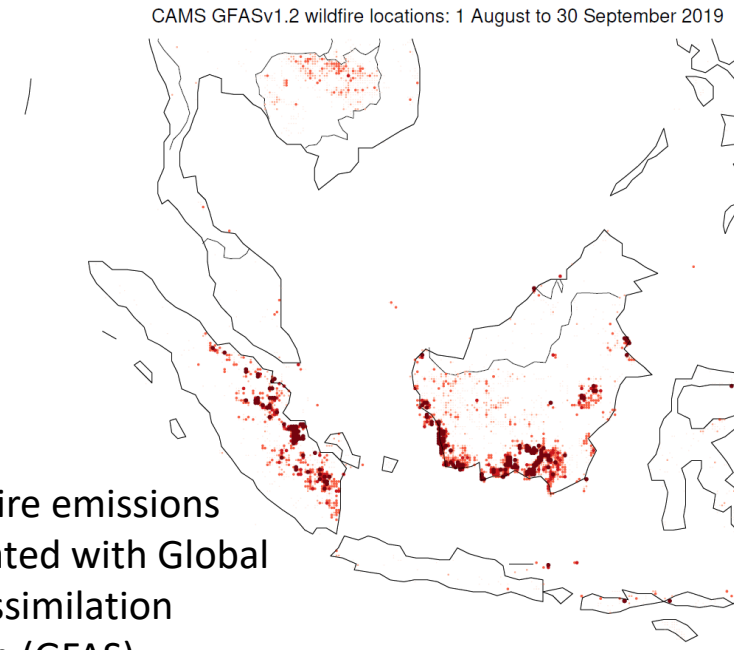


API Value	Band	Advice
Below 50	GOOD	Low pollution without any bad effect on health
51 – 100	MODERATE	Moderate pollution that does not pose any bad effect on health
101 – 200	UNHEALTHY	Worsen the health condition of high risk people who is the people with heart and lung complications
201 – 300	VERY UNHEALTHY	Worsen the health condition and low tolerance of physical exercises to people with heart and lung complications. Affect public health
Above 300	HAZARDOUS	Hazardous to high risk people and public health

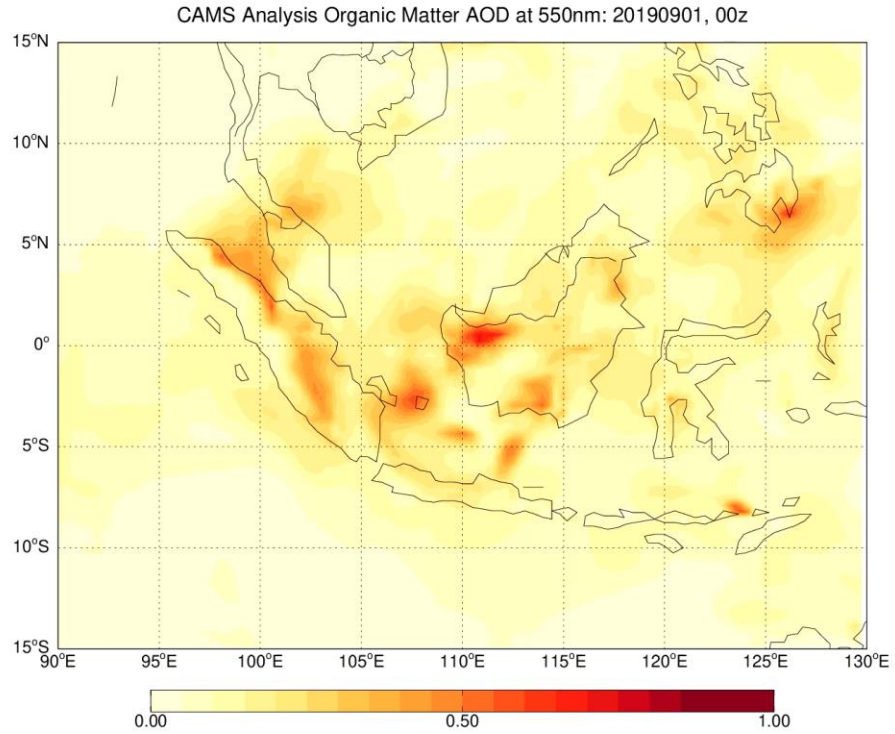
Health related - using Malaysian Air Pollutant Index

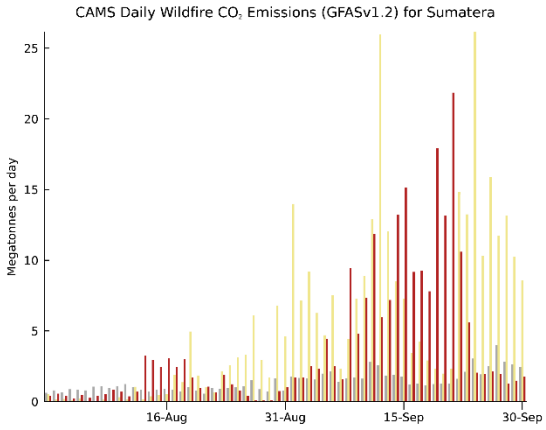
EU CAMS MONITORING 2019 Indonesian fires

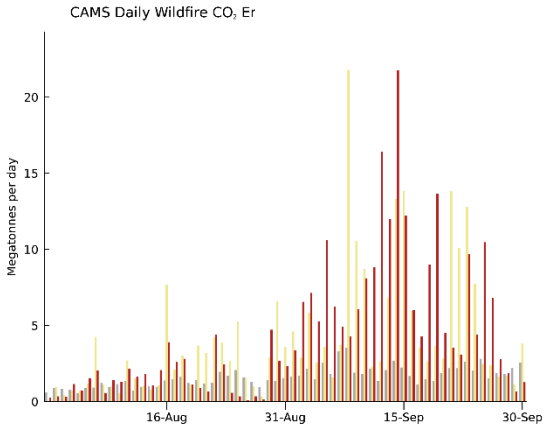
Analyses (assimilating satellite obs) and 5-day forecasts of atmospheric composition/air quality – organic matter aerosol as proxy for haze



Daily fire emissions estimated with Global Fire Assimilation System (GFAS)







http://atmosphere.copernicus.eu/

Thanks to Mark Parrington, ECMWF/CAMS

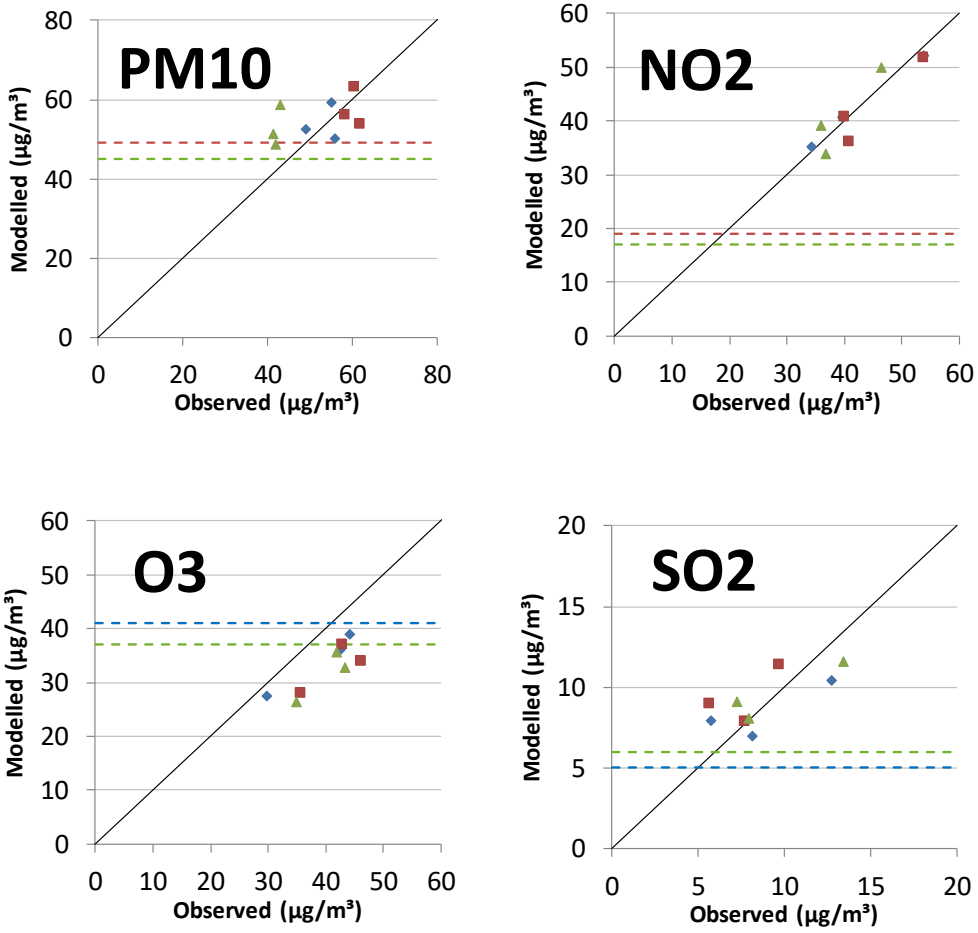
CERC

VERIFICATION OF ADMS-URBAN AIR QUALITY

Preliminary Findings

- Measured meteorology (Met Malaysia) as input
- Measured hourly air quality (DOE) for background and to compare with predictions

Annual averages (2014-16)



Statistics for hourly predictions

Poll.	Year	Fb	NMSE	R	Fac2
PM_{10}	2014	0.01	0.38	0.62	0.81
	2015	-0.05	0.31	0.76	0.78
	2016	0.23	0.25	0.55	0.81
NO_2	2014	0.00	0.27	0.52	0.82
	2015	-0.05	0.29	0.45	0.79
	2016	0.03	0.29	0.46	0.80
NO_x	2014	-0.03	0.39	0.62	0.76
	2015	0.05	0.35	0.61	0.75
	2016	0.05	0.39	0.56	0.76
O_3	2014	-0.12	0.62	0.81	0.41
	2015	-0.24	0.70	0.80	0.38
	2016	-0.24	0.70	0.79	0.39
SO_2	2014	-0.05	1.24	0.21	0.57
	2015	0.20	1.78	0.15	0.53
	2016	0.00	1.15	0.18	0.54

Fb = Fractional bias, NMSE = normalised mean square error, R = correlation, Fac2 = fraction within 2x

CERC

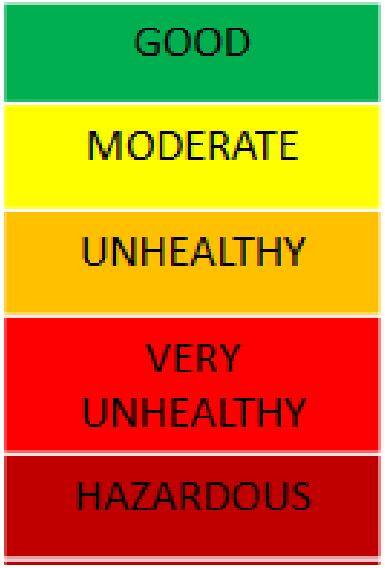
UKM PAKARUNDING

VERIFICATION OF AIR QUALITY FORECASTS

Preliminary Findings

- Hindcasting for 24 May 2019 to 16 Sep 2019
- Used archived met forecasts (Met Malaysia) and global air quality forecasts (EU CAMS) to determine what system would have predicted 2 days in advance
- Compared forecast and observed Malaysian Air Pollution Index bands:

API Bands



Station	Pollutant	Number of points	Time period	Within correct band or out by one band
BM	NO2	90	Days	90.0%
C	NO2	89	Days	94.4%
PJ	NO2	92	Days	83.7%
BM	O3	2091	Hours	98.9%
C	O3	2150	Hours	98.9%
PJ	O3	2177	Hours	99.8%
BM	PM10	92	Days	100.0%
C	PM10	92	Days	100.0%
PJ	PM10	92	Days	100.0%
BM	PM2.5	92	Days	98.9%
C	PM2.5	92	Days	98.9%
PJ	PM2.5	92	Days	98.9%

Stations: BM = Batu Muda, C= Cheras, PJ = Petaling Jaya
Measured data provided by DOE

Thanks to all colleagues in the Disaster Resilient Cities project

Particularly Prof Talib (UKM), Mr. Ammar (Met Malaysia), Dr. Azlan (CoRE), Dr Kai Wang (UCL)

Mark.Jackson@cerc.co.uk

Cambridge Environmental Research Consultants, UK