Workshop on Status of Climate Science and Technology in Asia
15-16, November 2018, Kuala Lumpur, Malaysia

Climate Science and Technology for Cities

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[5] *SEADPRI, Universiti Kebangsaan Malaysia*

Summary

- This presentation aims to show features of interactions, modelling, data, significant applications, and considerations of urban policies.

ipcc
INTERGOVERNMENTAL PANEL ON climate change

GLOBAL WARMING OF 1.5 °C

an IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty

SEARCH The New York Times

Opinion

Heat and Humidity Are a Killer Combination

By Ethan Gotlel, Radley Horton and Colin Raymond

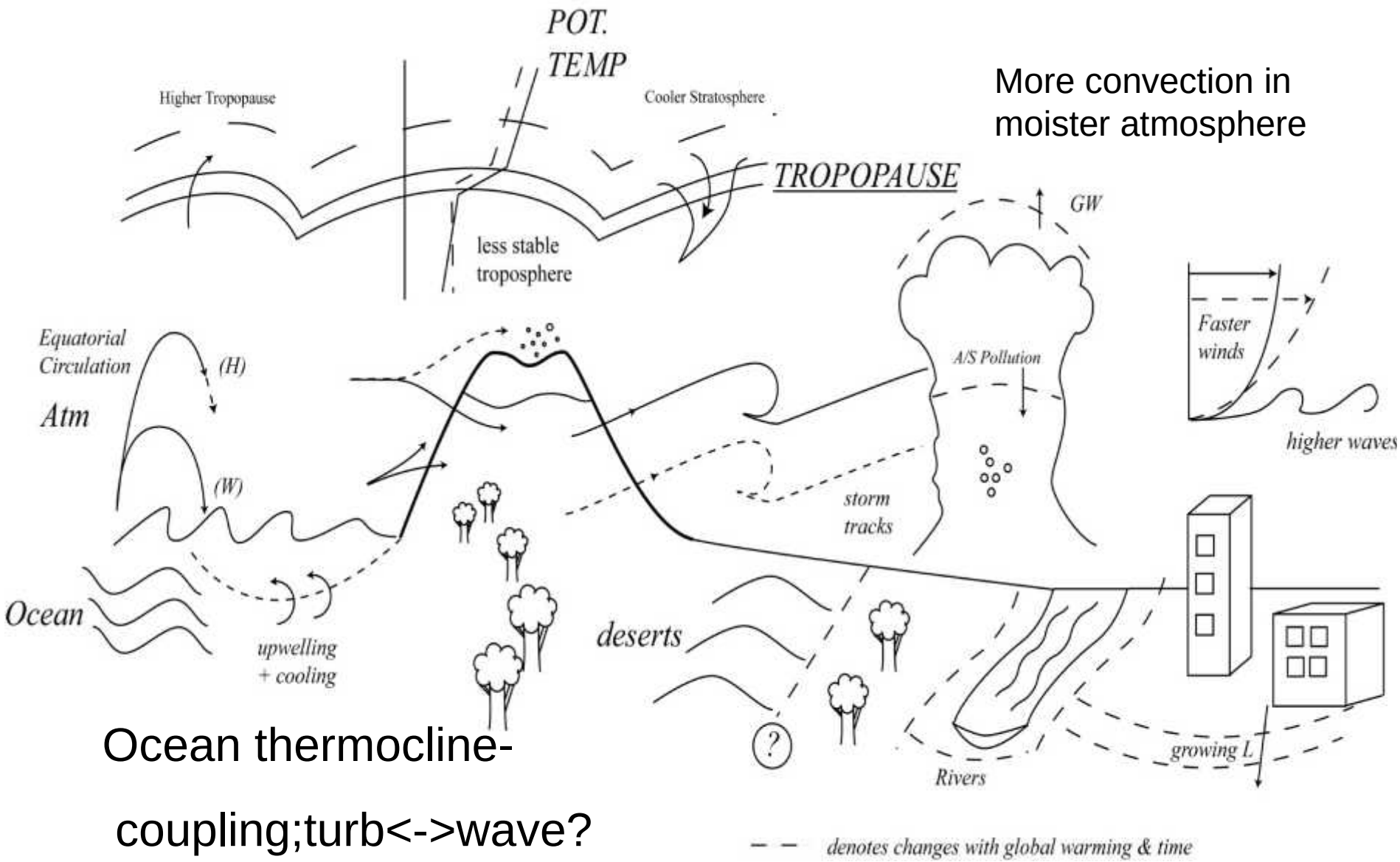
The authors are climate scientists at Dartmouth College and Columbia University

Graphics by Sahil Chinoy and Bill Marsh

New solutions needed

Schematic Diagram of Climate Change Processes

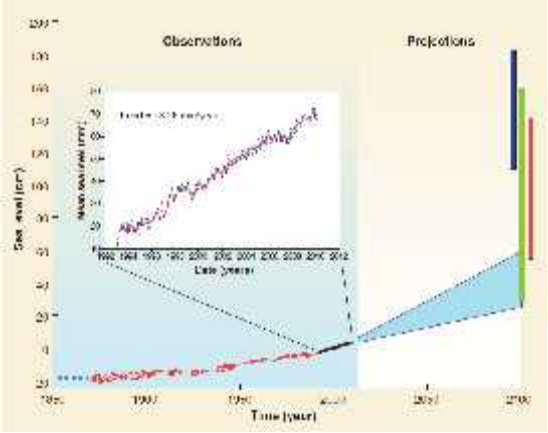
More convection in moister atmosphere

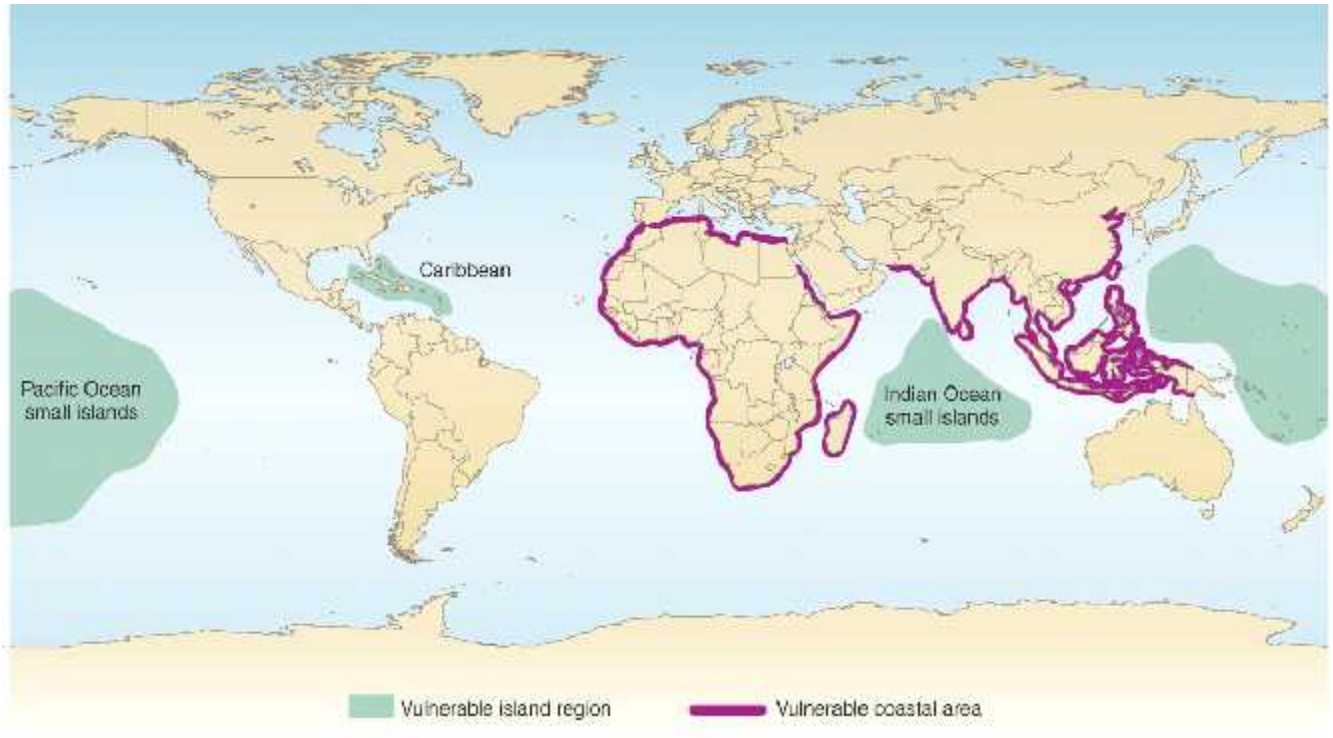


Ocean thermocline-

coupling;turb<->wave?

Sea Level Rise





- dense populations
- low elevations
- appreciable rates of subsidence
- inadequate adaptive capacity.

Areas that are vulnerable to coastal flooding caused by future relative or climate-induced sea-level rise.

There are engineering solutions in other critical areas

Nicholls & Cazenave, *Science*, 2010

Tropical cyclones – trends in time and space - toward equator?

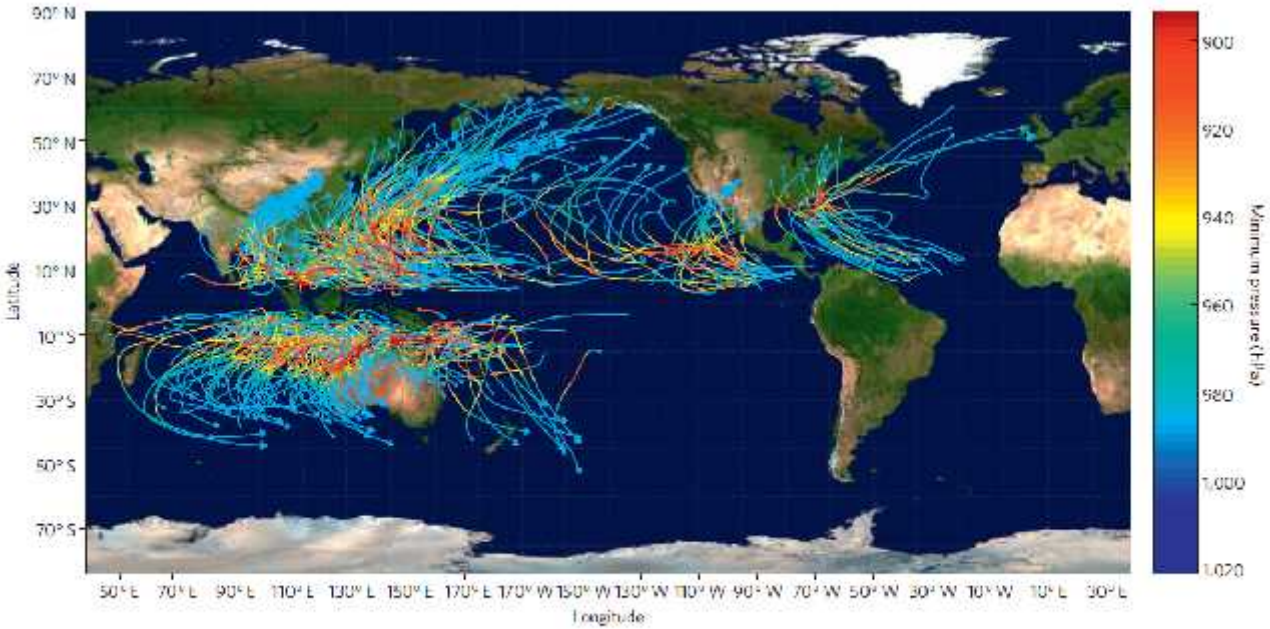
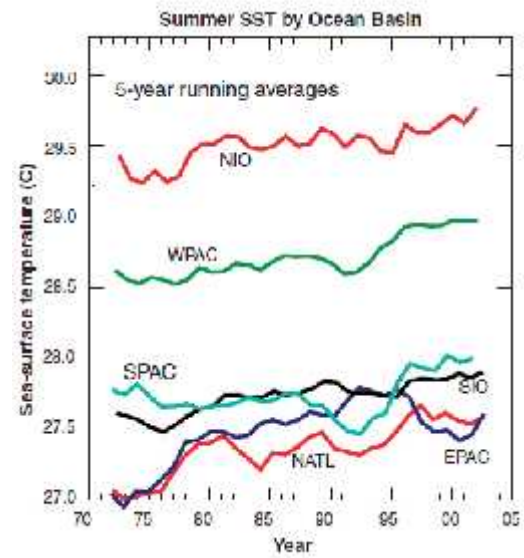
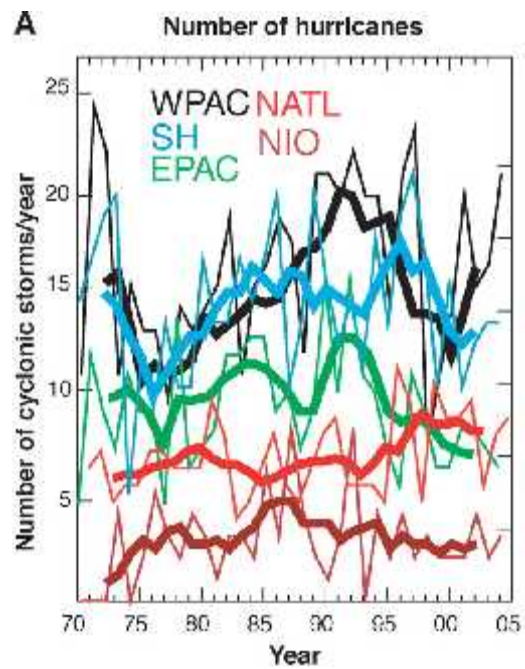


Figure 1 | Storm tracks and minimum pressure for a sample of synthetic storms. The tracks show that storms are more frequent in the western Pacific. The minimum pressure (hpa) or storm intensity is measured by their colour. Storm intensity is higher over the warm waters near the Equator and lower over the cooler waters towards the poles.

Mendelsohn, et al. Nature climate change 2012.





Webster, et al. Science, 2005

Regional weather forecasting

Weather forecasts days ahead need global data, but high resolution (≤1km) global numerical forecast models are too expensive

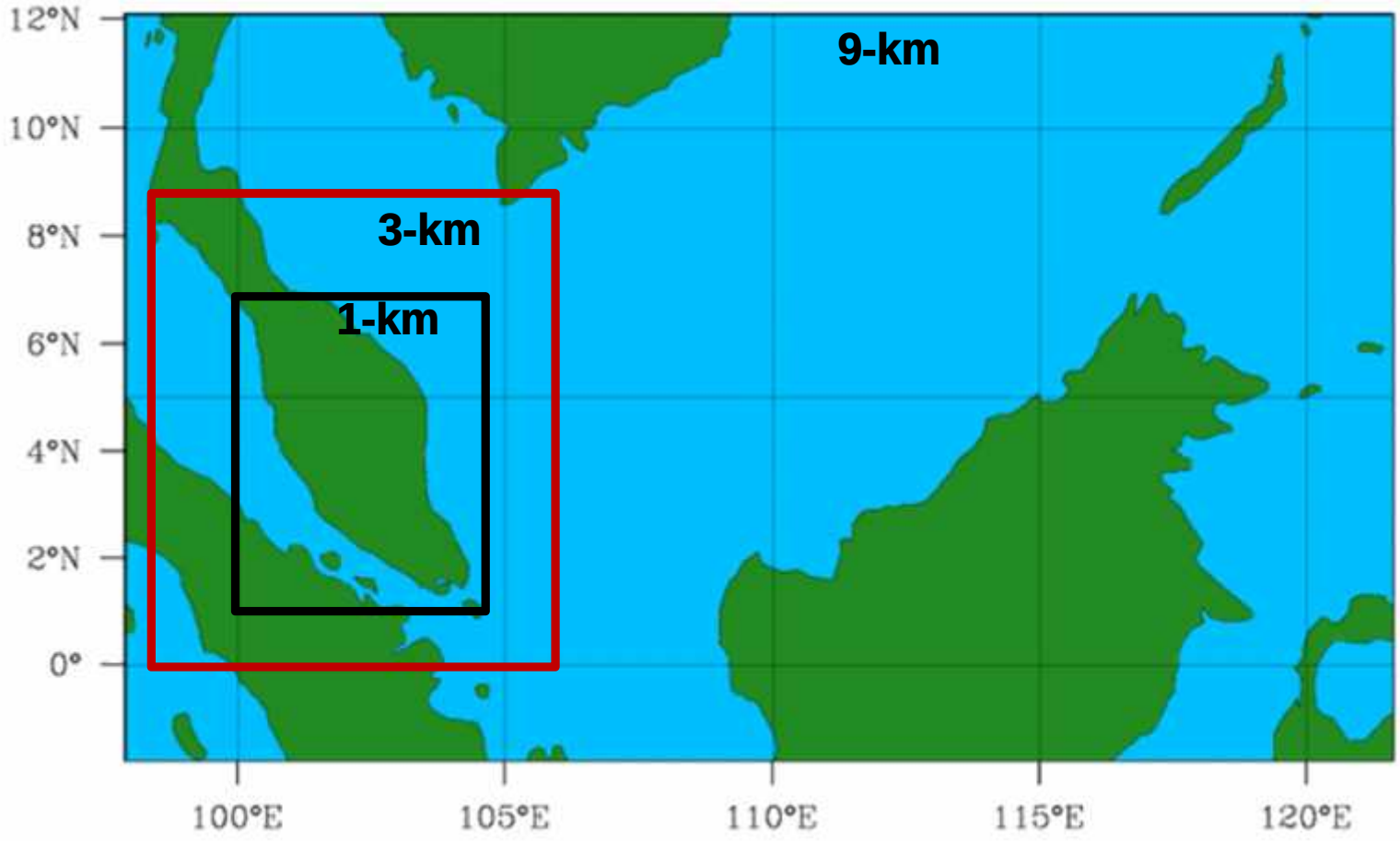
Strategy: use information from a lower resolution (≥10km) forecast to drive high resolution regional forecasts

E.g. MetMalaysia use 3 nested models, with
boundary conditions from a global forecast for the outer domain

The inner domain can in turn be used to drive **urban models**
such as for KL

WRF MODEL DOMAINS

nested within global model



provides input to high resolution urban models

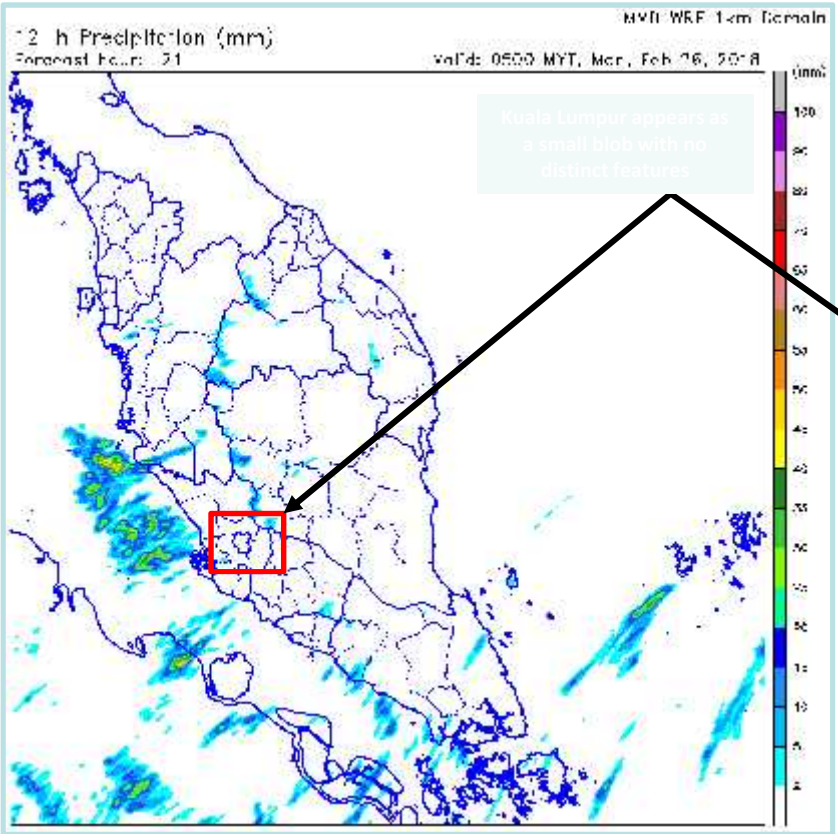
Mesoscale weather forecasting

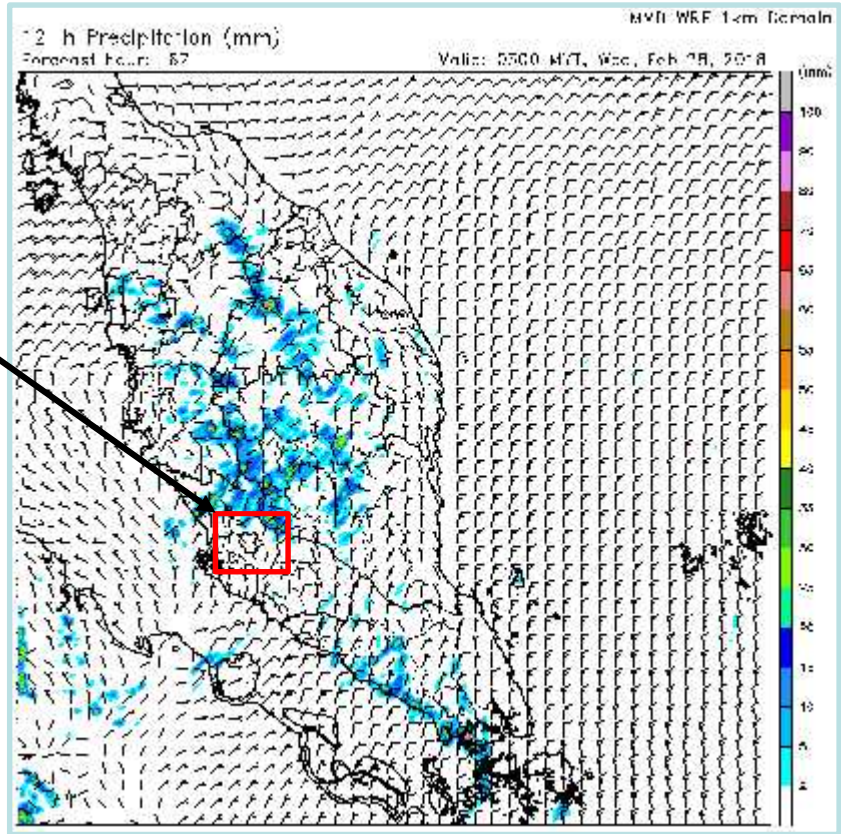
There are **weather processes** specific to the tropics

– clouds, deep convection, tropical cyclones influenced by ocean-atmosphere interaction (turning to tropical storms nearer the equator), …..

To what extent should <u>general circulation models</u> be adapted for **tropics – regional/urban forecasting** ??

CURRENT MODEL OUTPUT PRODUCT WHICH DOESN’T CATER FOR KUALA LUMPUR SPECIFICALLY





Typhoon Haiyan 2013

Typhoon was so strong that water was blown off shallow seas regions

More complex modelling required ….

Getty Images

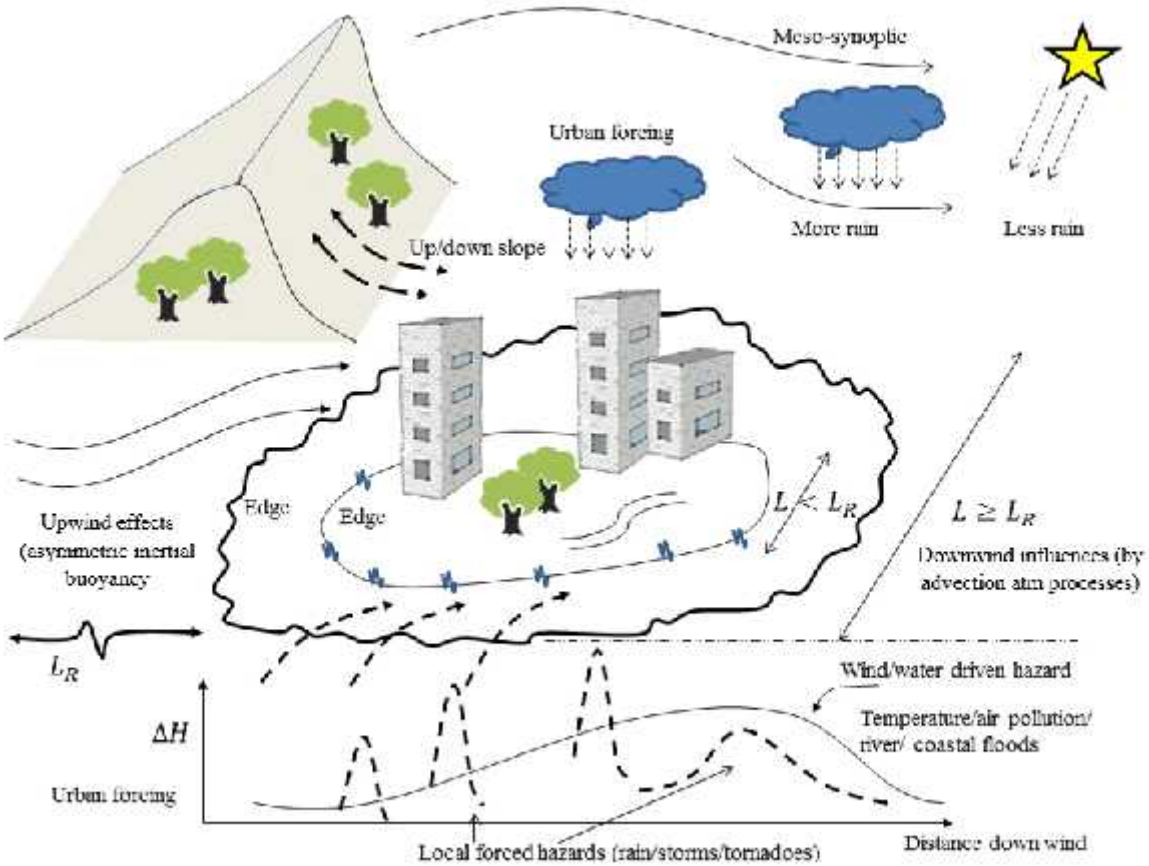
Super Typhoon Haiyan moves towards the Philippines

"It is the most powerful storm ever to make landfall," Weather Channel lead meteorologist Michael Palmer told NBC News. "It is as strong a typhoon as you can get, basically."

Haiyan made landfall with winds near 195 mph. Typhoons and cyclones of that magnitude can blow apart storm-proof shelters due to the huge pressure they create, which can suck walls out and blow roofs off buildings.

Authorities in the Philippines earlier warned that 12 million people are at risk.

Climate effects in large urban areas

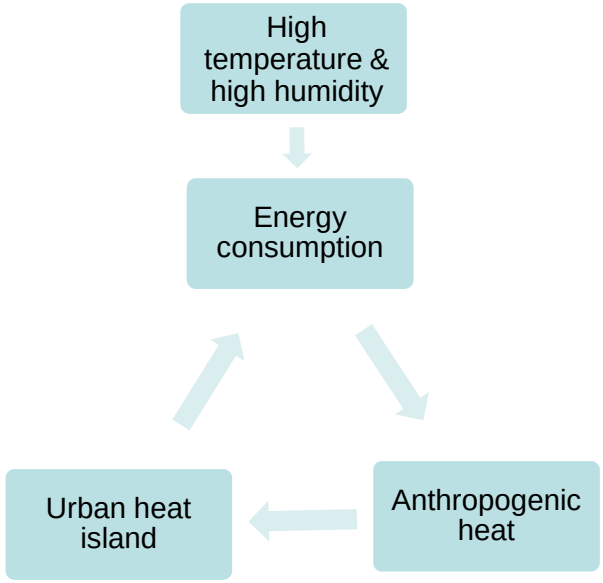


- Trends: urbanisation of global pop 60-70%
- Megacities: pop~ 10 million L~ 30-100km

- Greater hazards – location? contribution to global trends?
- Greater vulnerability – environmental; geophysical
- Economic – supplies; trade; global effects

Special features in tropical cities

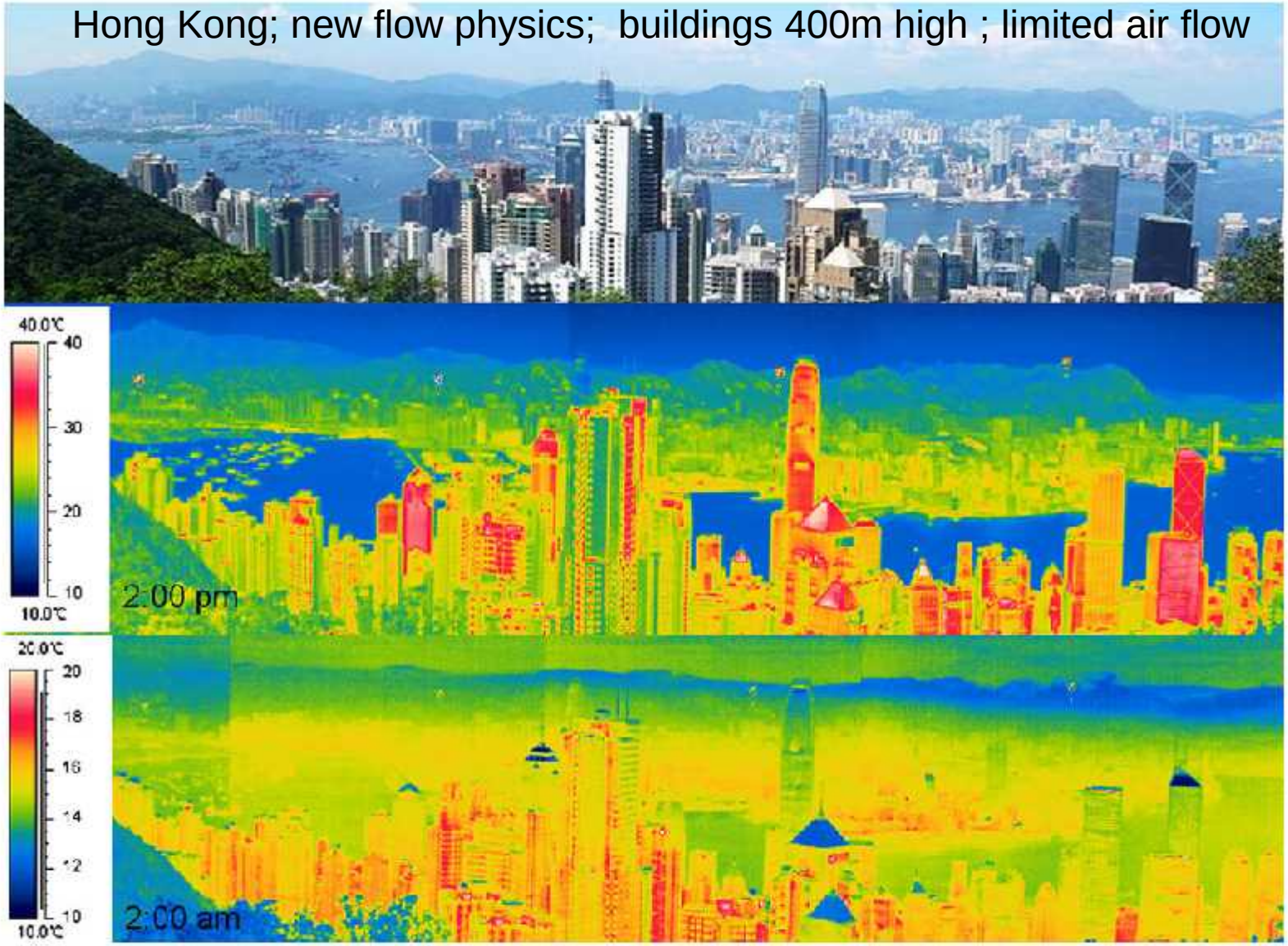
- Building morphology – density; heterogeneity
- High temperature – cooling load; energy consumption…
- High humidity – human comfort; energy consumption; rainfall…
- Low wind – poor dispersion; urban heat; air pollution (internal, external) …






COMPLEX METEOROLOGY AND ENVIRONMENT OF A MEGACITY

Hong Kong; new flow physics; buildings 400m high ; limited air flow



M i d d a y

N I G H T

Fig. 2. The photo of the buildings and corresponding infrared images at 2 pm and 2 am on March 15–16, 2008. Note that the four repeated color pixels followed by a sequence of red dots in the 2 pm image (and also the corresponding dots in the 2 am image) were due to the camera defect without affecting the measurement at other points.

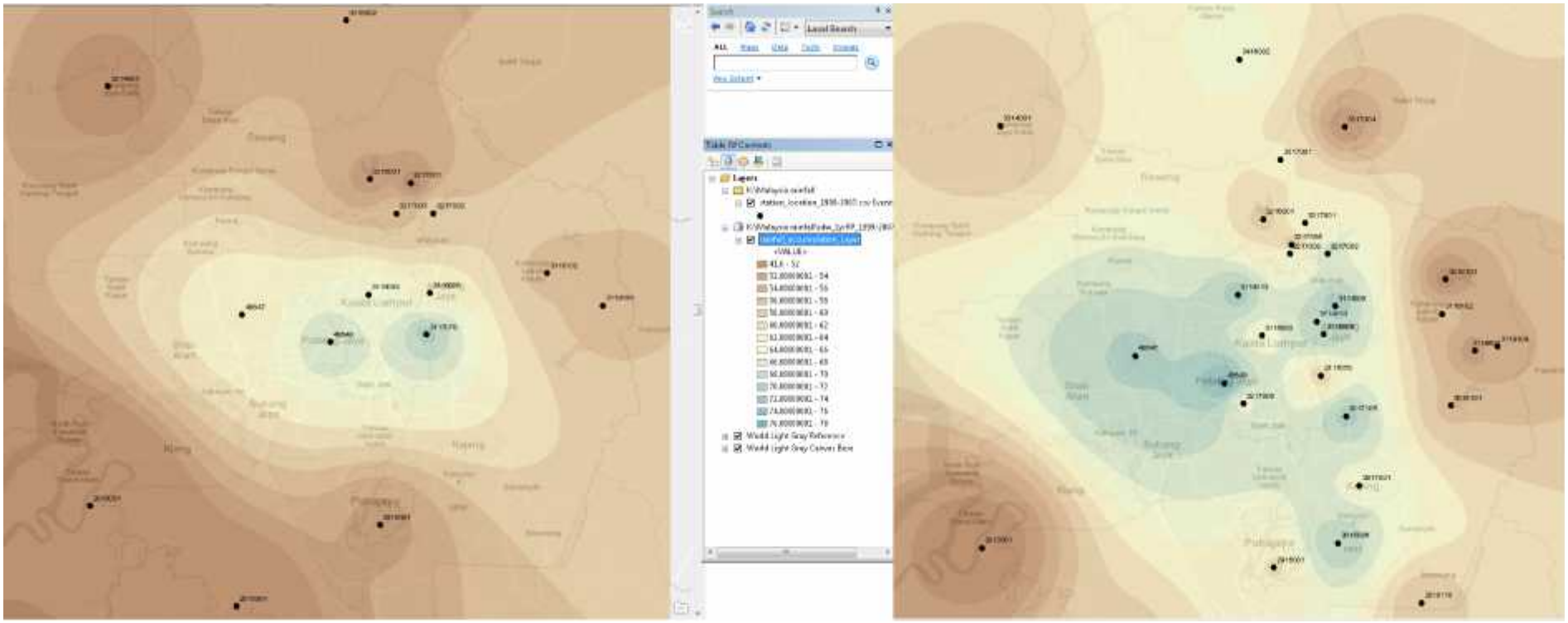
Prof Yuguo Li –HKU. COOL TALL TOWER _RADIATION COOLING

From Mark Saunders (UCL): work in progress for NUO Resilient Cities using rainfall station data provided for the project

1-Year Return Level of Extreme 1-hour Rainfall in the vicinity of KL

1999-2007

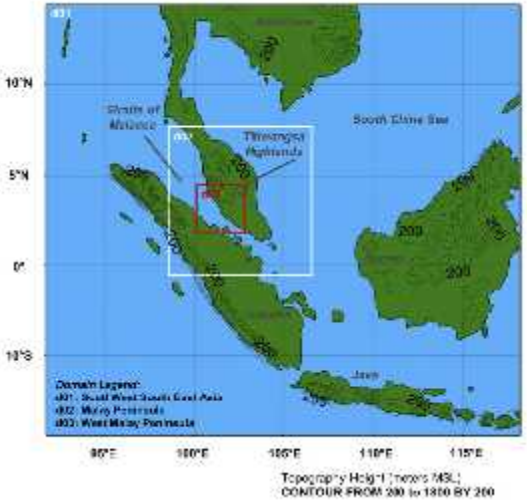
2008-2016

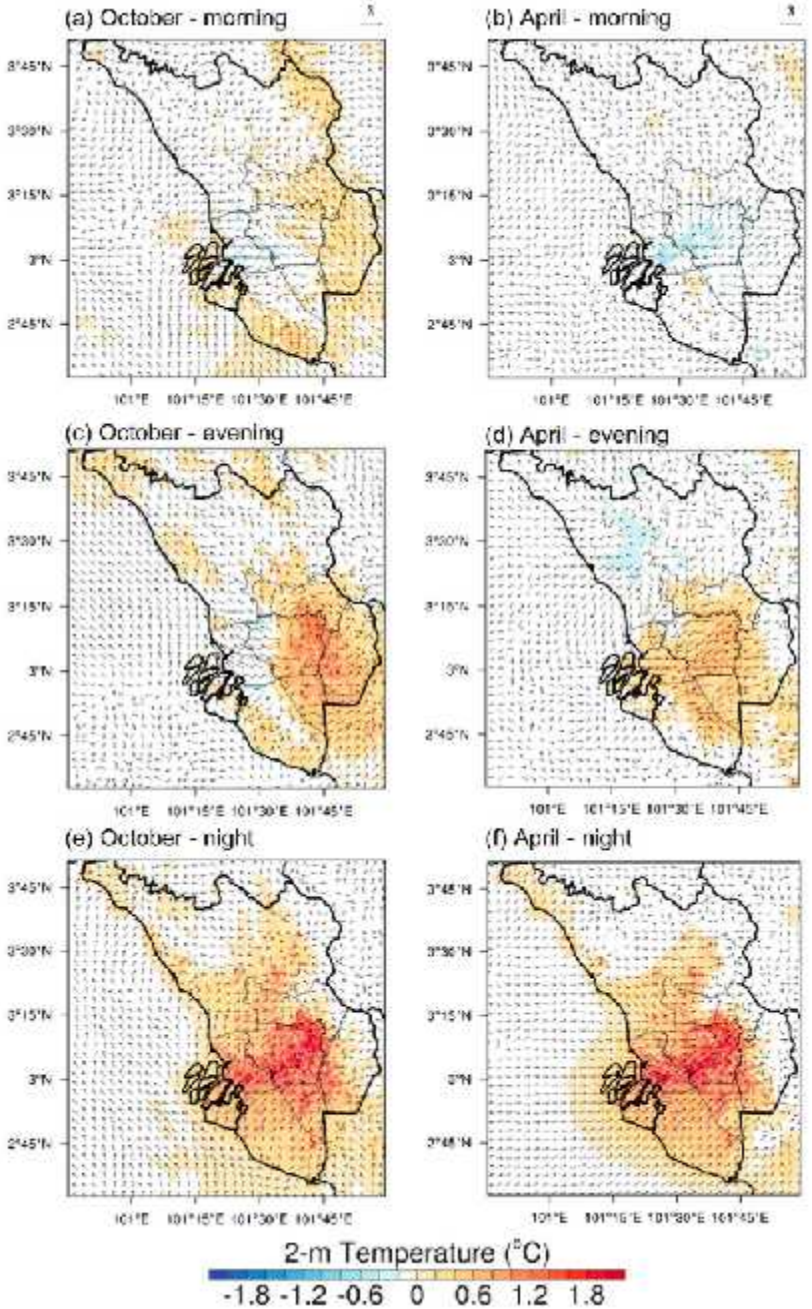


- heavier rainfall in KL than in surrounding less urban areas
- frequency of extreme rainfall events is increasing
- modelling (e.g. Hong Kong)suggests orography, forestry,… effects

WRF-UCM

Urban heat





morning

evening

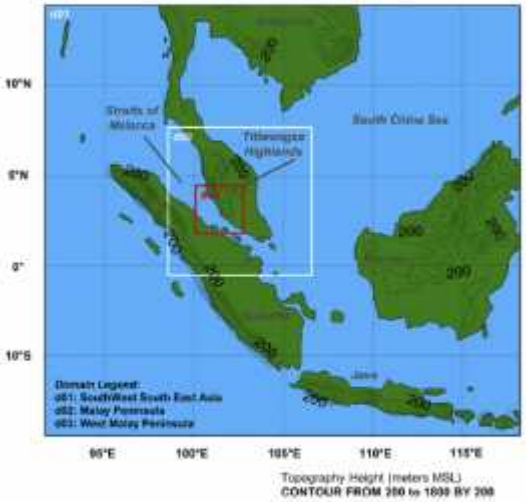
night

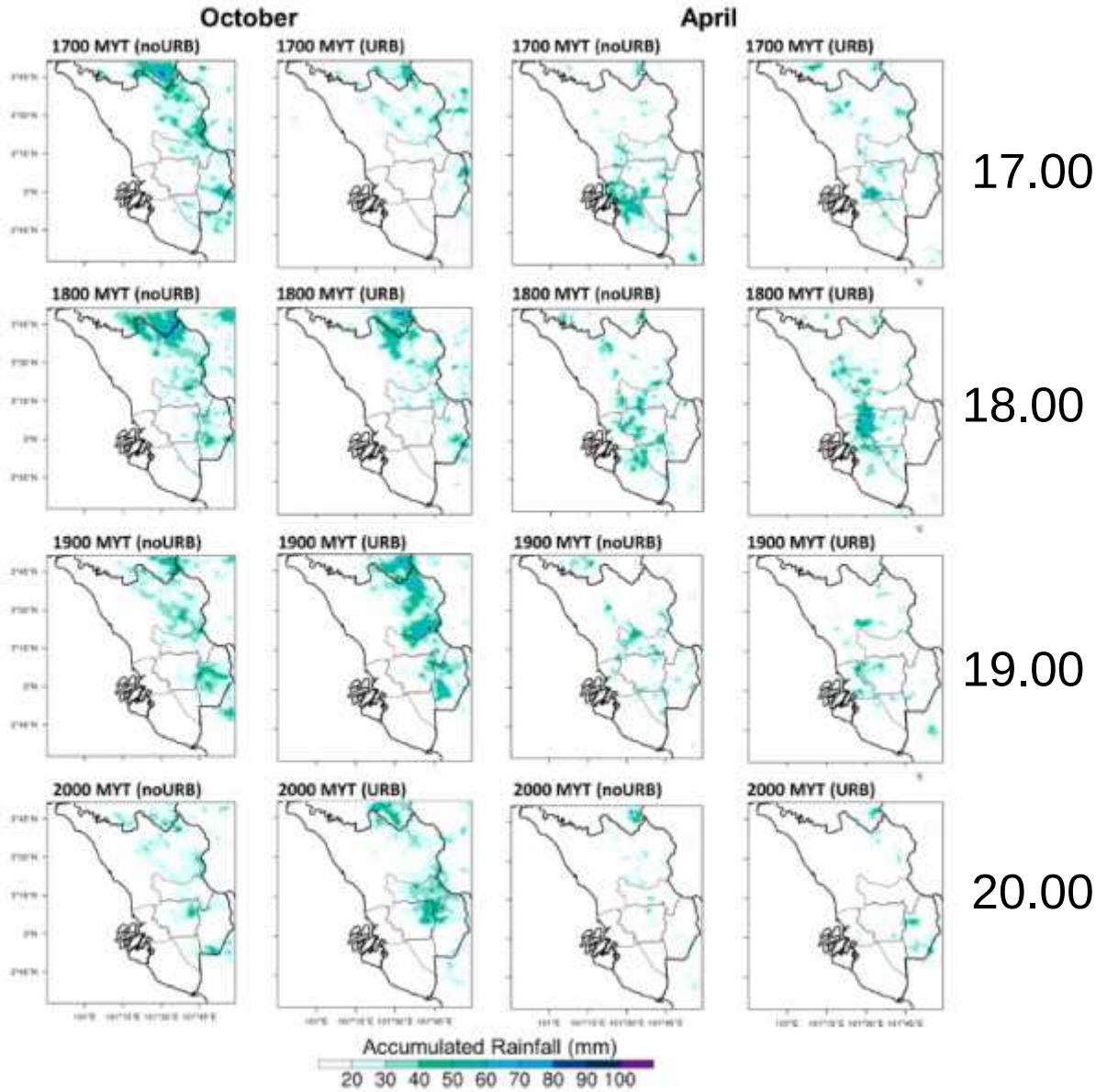
April: lower UHI at 1500 to 1800 due to convective precipitation

Ooi, et al. JGR, 2017 (U Nottingham Malaysia Campus, KL; MMD, etc)

WRF-UCM

Rainfall



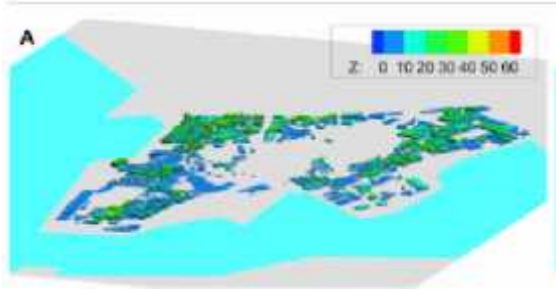


Ooi, et al. JGR, 2017

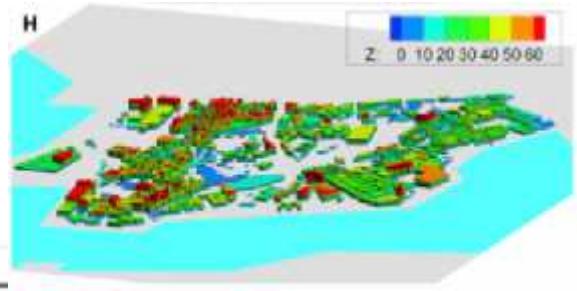
CFD

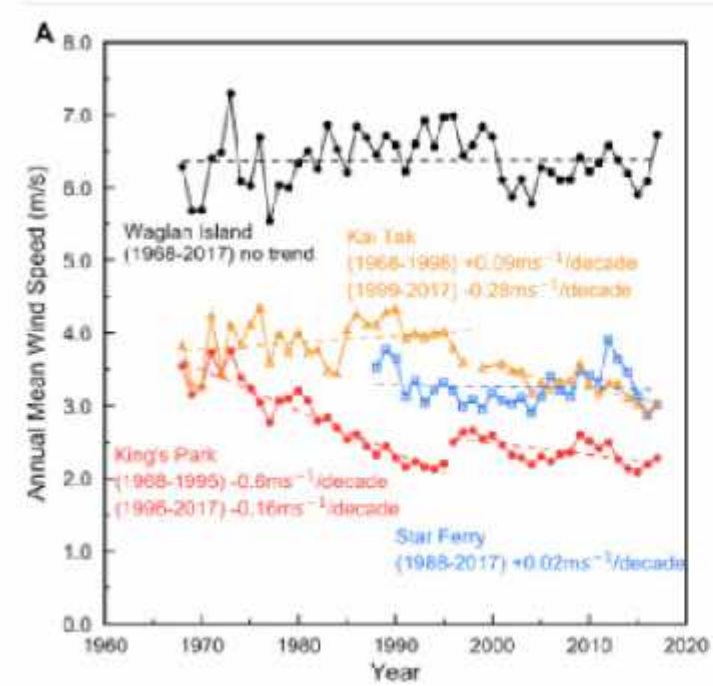
Wind weakening due to denser and higher buildings

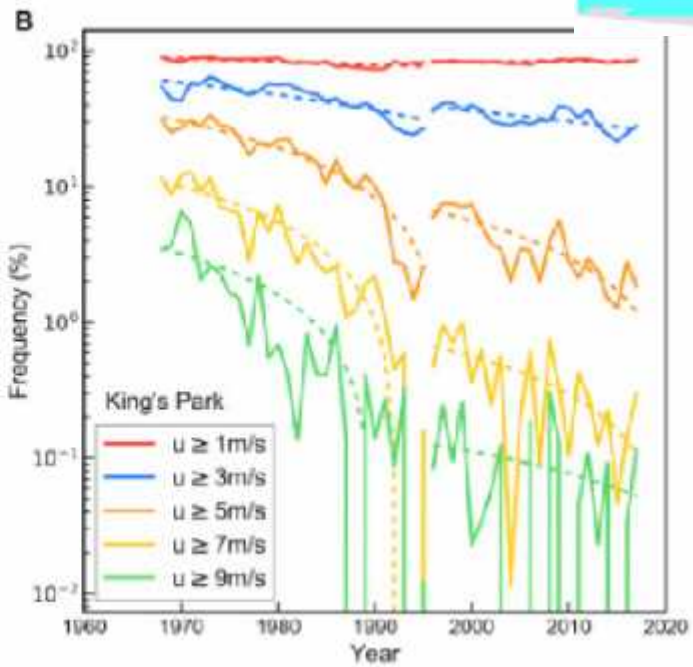
1964

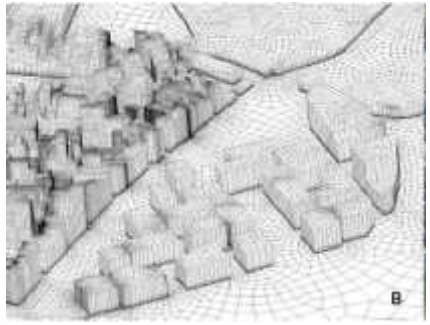


2010









observed

CFD modelling

Peng, et al. Energy&Blgs, 2018

Dispersion of pollution in streets

-v

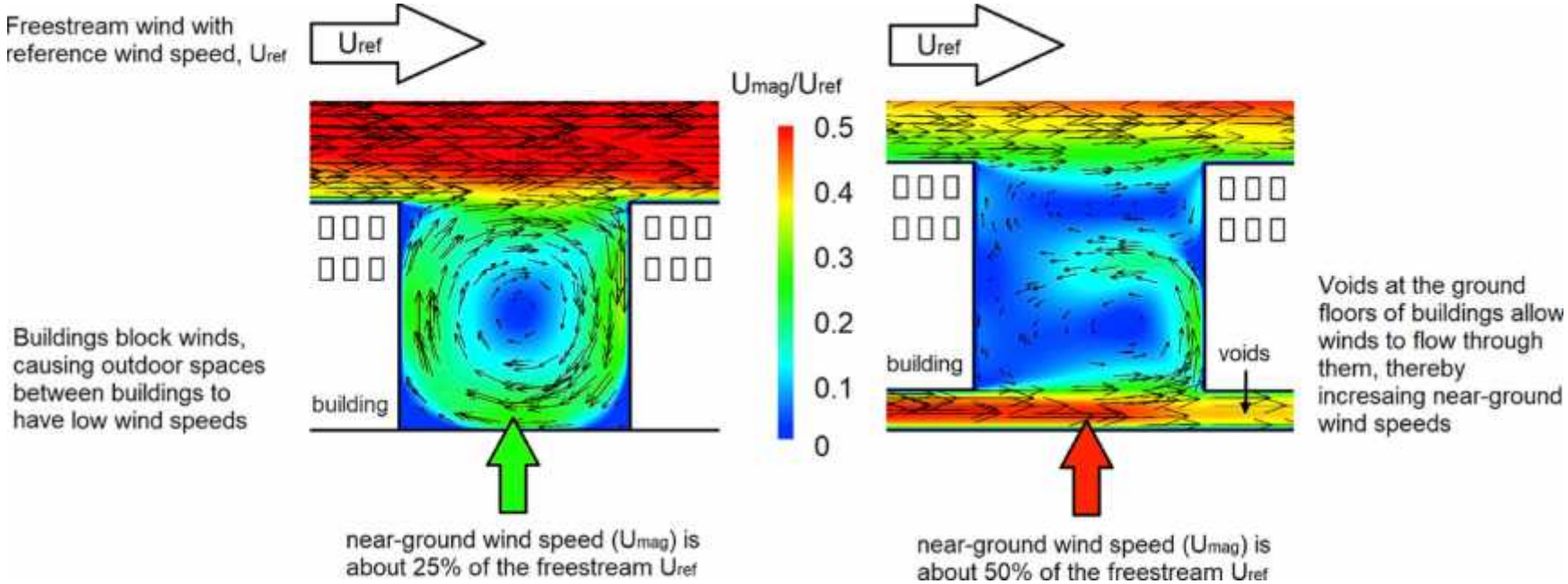
Local

Effects-

complex variation of pollution below buildings-but pollutants mix up to inversion layer above buildings. (deterministic or statistical methods)

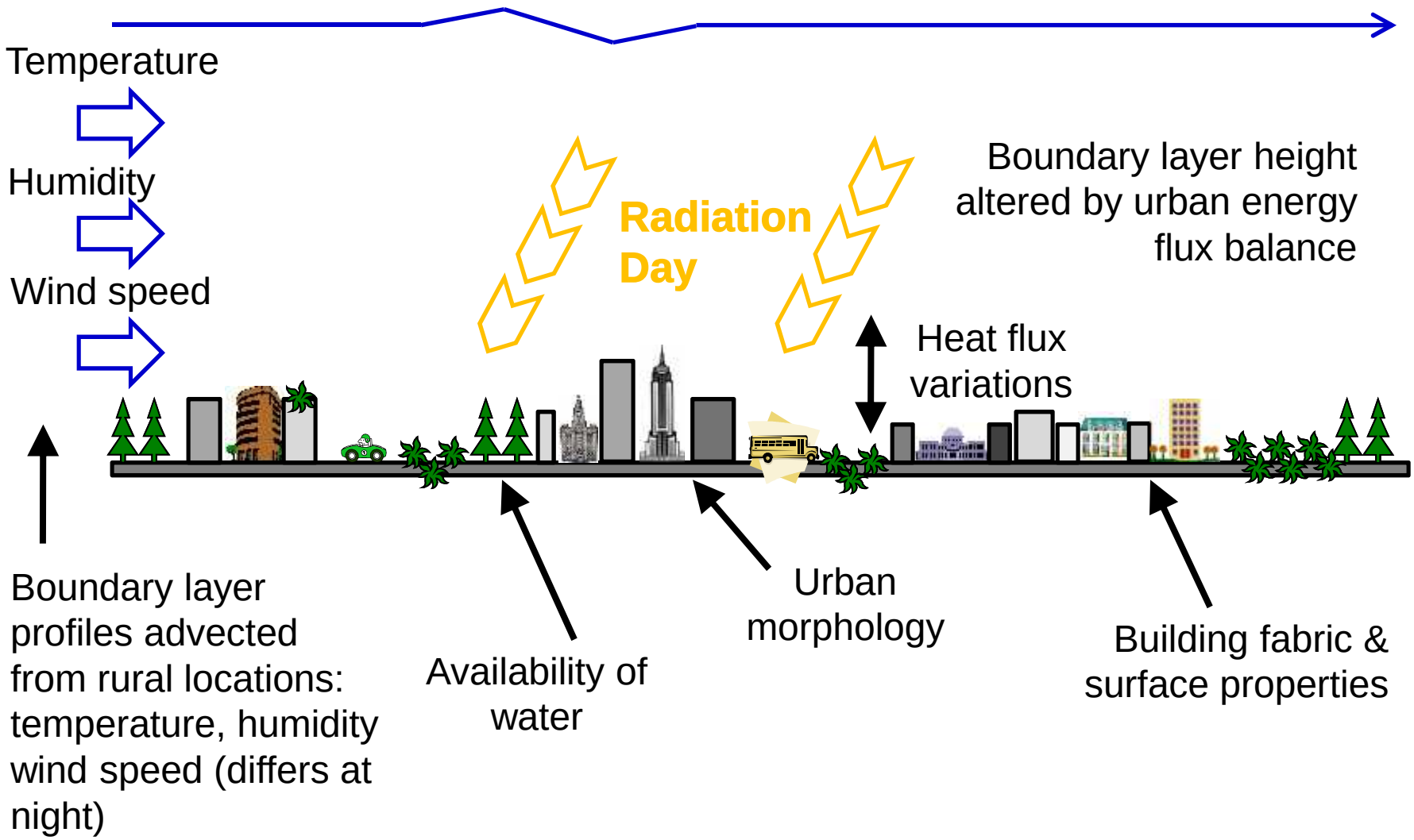
CFD and physical modelling

Pedestrian-level wind speed enhancement



Chew & Norford, Building and Environment,2018

Localised model: ADMS-Urban features



Parameterising urban datasets

- How are the local variations and anthropogenic heat sources derived?

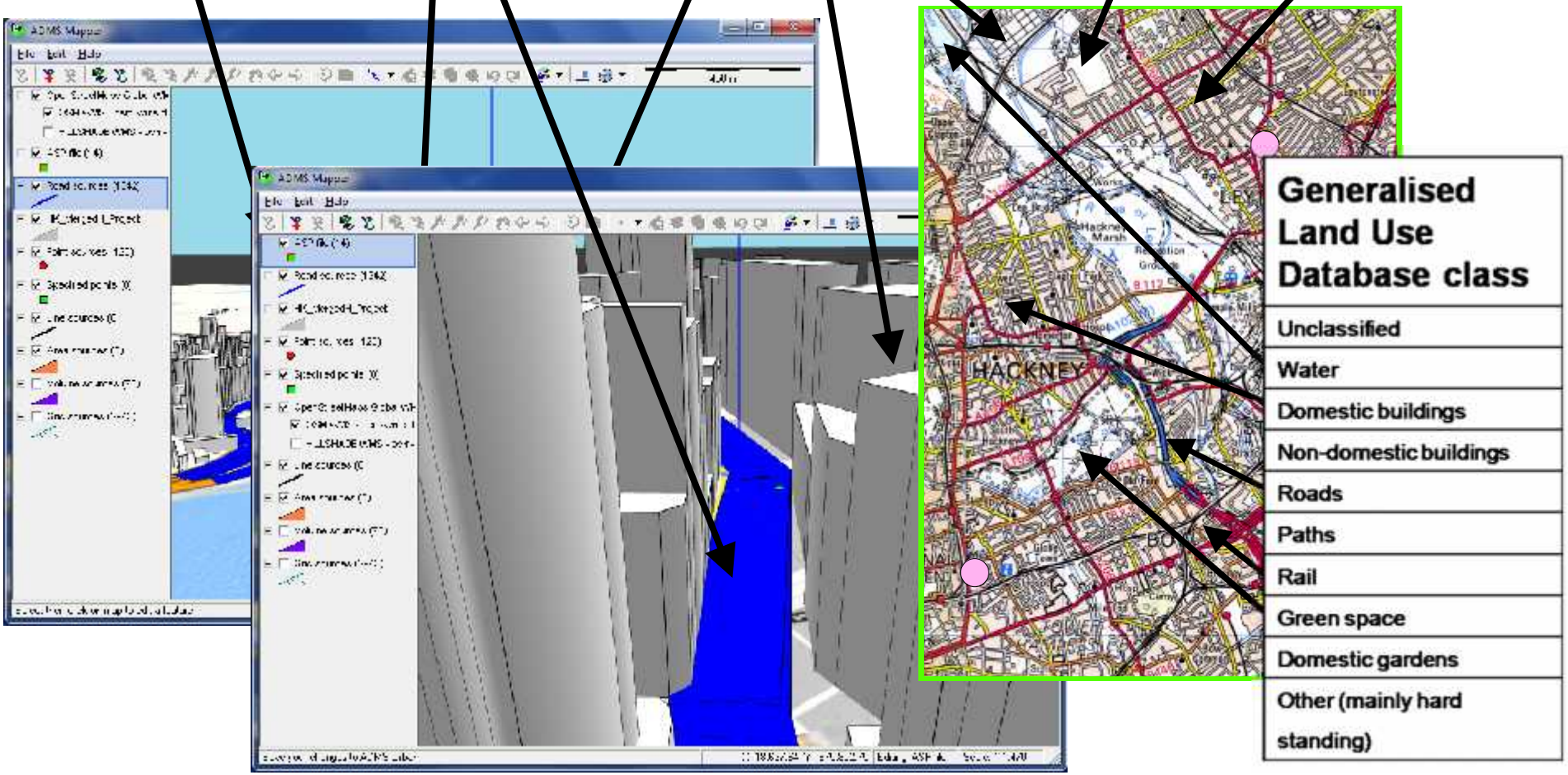
Local changes in roughness

Anthropogenic heat from buildings & roads

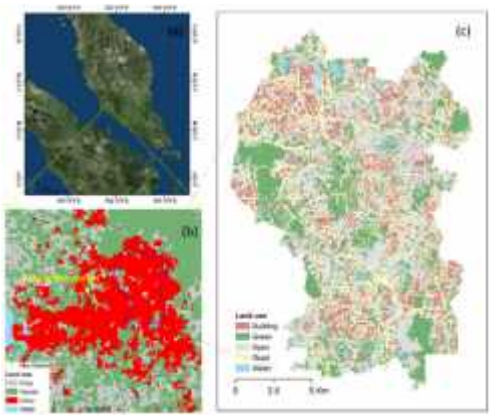
Local albedo & building geometry

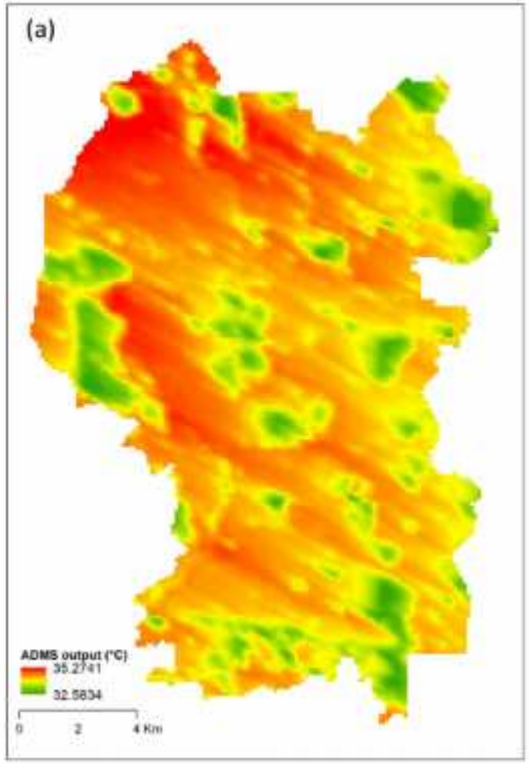
Local availability of moisture

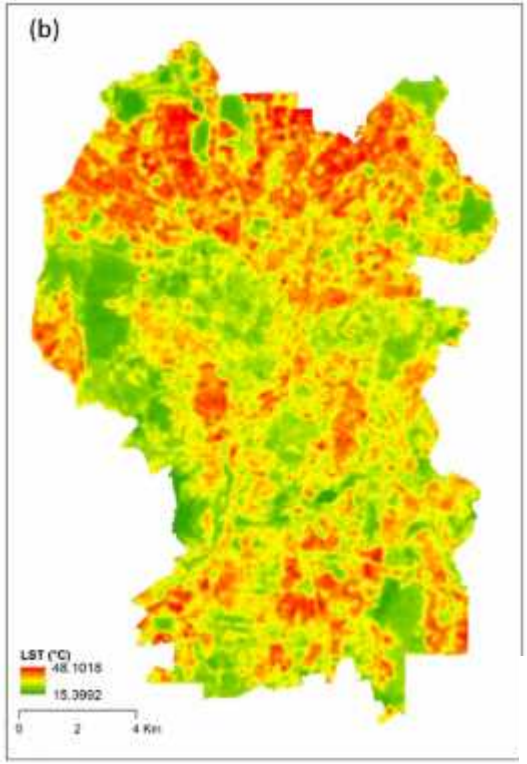
Thermal properties of the surfaces



Model results: Kuala Lumpur

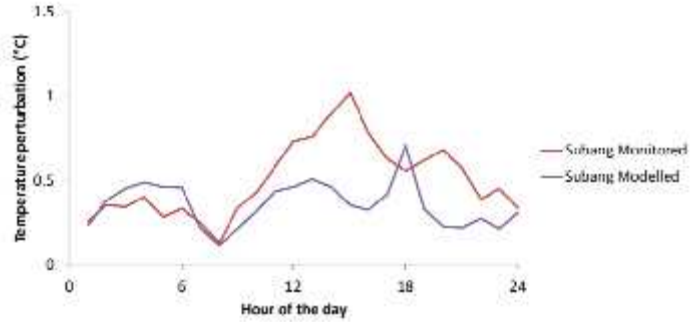


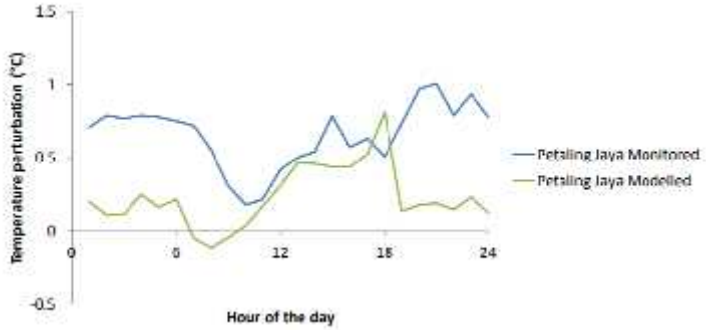




ADMS model

Satellite images



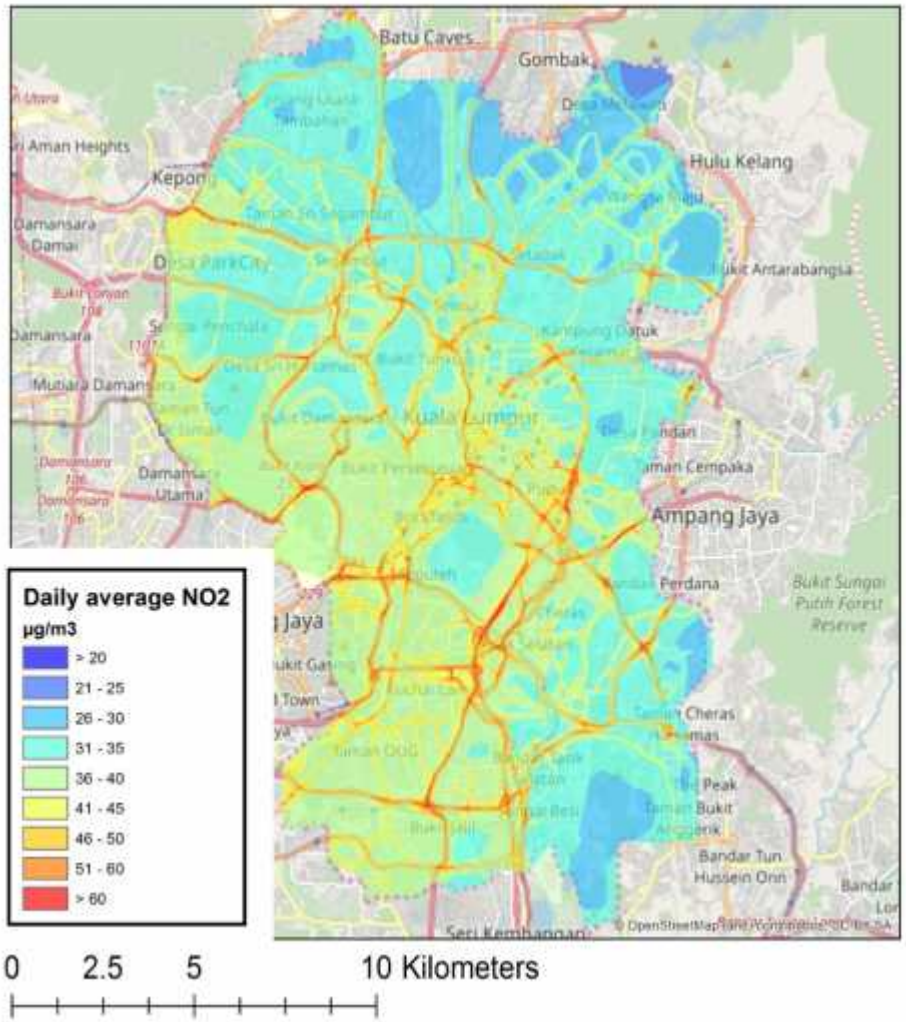


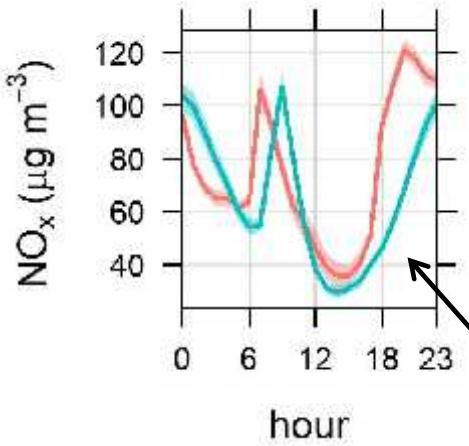
More data needed:

- Detailed land use data outside KL city
- Hourly meteorological station data for upwind input and validation

AQ model results: Kuala Lumpur

Daily average NO2 inside KL city boundary, 1 June 2014



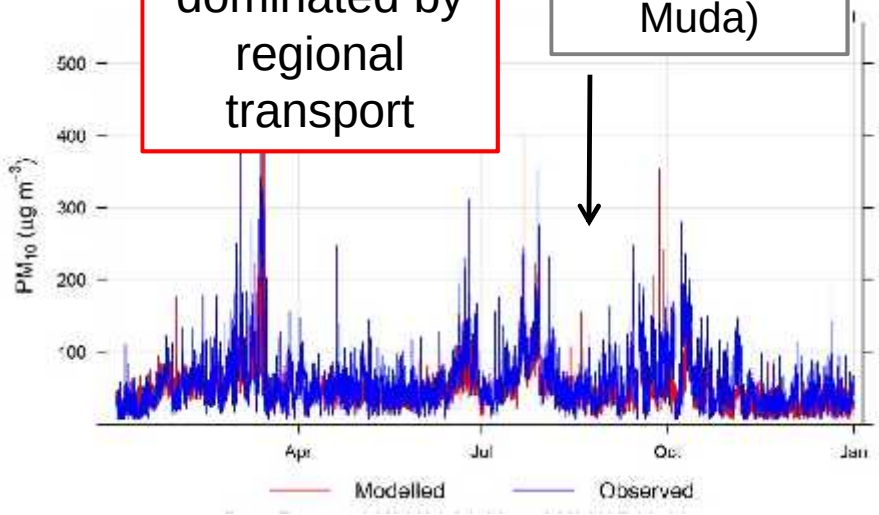


Good agreement for usual traffic pollutants

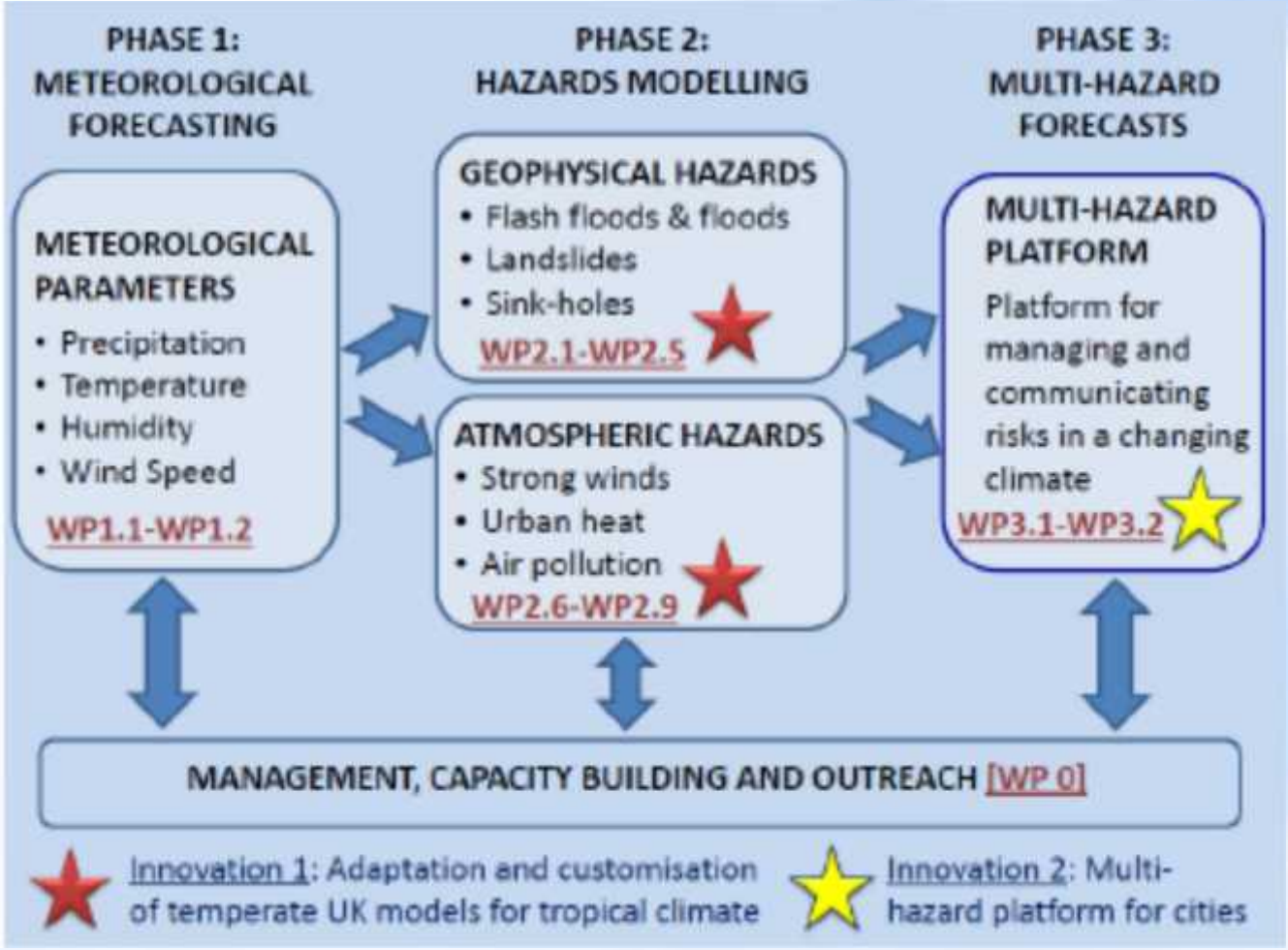
Average diurnal variation (NOx, Cheras)

Good agreement for PM – dominated by regional transport

Time series (PM10, Batu Muda)



Approach and Innovation Features



This serves as the basis for framing the project around three phases:-

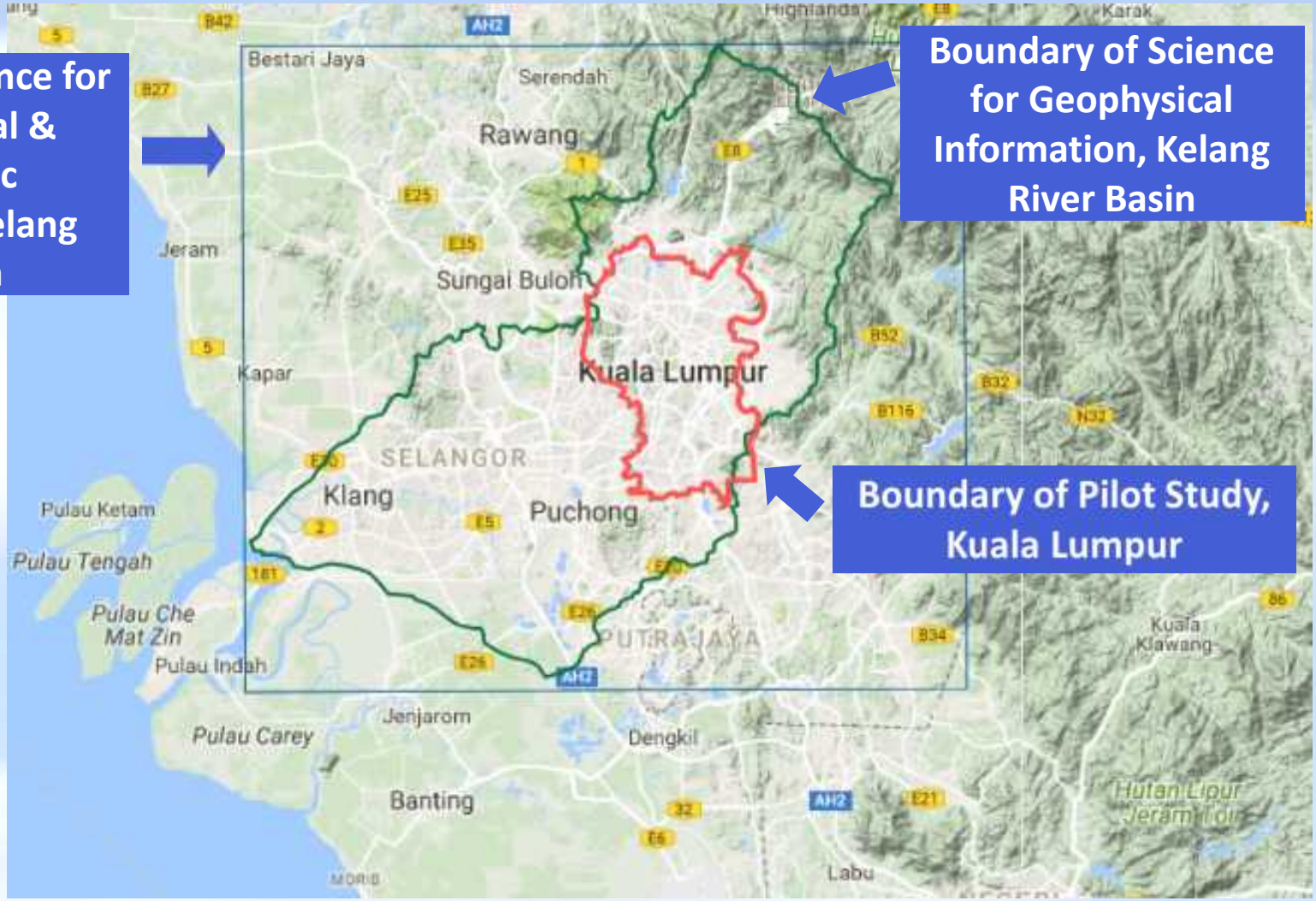
- **Phase 1 is on Meteorological Forecasting;**
- **Phase 2 is on Hazards Modelling; and**
- **Phase 3 is on Multi-hazard Forecasts.**

Each Phase comprises several work packages (WP) with innovation features

Deliverables will be achieved over 34 months.

Details are specified in the Gantt Chart

Risk Register has been developed


Boundary of Science for Meteorological & Atmospheric Information, Kelang River Basin
Boundary of Science for Geophysical Information, Kelang River Basin
Boundary of Pilot Study, Kuala Lumpur
Bestari Jaya
Serendah
Rawang
Jeram
Sungai Buloh
Kuala Lumpur
Kapar
SELANGOR
Klang
Puchong
Pulau Ketam
Pulau Tengah
Pulau Che Mat Zin
Pulau Indah
PUTRAJAYA
Jenjarom
Pulau Carey
Dengkil
Banting
Labu
Kuala Klawang
Karak

NUOF project: Multi-Hazard Platform

Multi User

- Kuala Lumpur City Hall (DBKL)
- Ministry of Federal Territories
- National Disaster Management Agency
- Department of Town and Country Planning
- Department of Irrigation and Drainage
- Malaysia Civil Defence Force (APM)
- Public Works Department (JKR)

Floods / Flash Floods

Landslides

Sink Holes

Front-End Graphics Server

Backend Database Server and Data Processing Engine

Meteorological

Atmospheric Hazards

Supplementary Studies / System

- Input:
  - hazard models provide physical risk information for next few days
- Output:
  - Decision ‘theatre’-> tailored products for decision makers

Project Management, Capacity Building & Outreach

Designed to deliver directly to the Local Council:
City Hall of Kuala Lumpur (DBKL)

Ensure multi-hazard platform interoperability with national system: NADMA

Explicit involvement of key stakeholders through the Project Steering Committee.

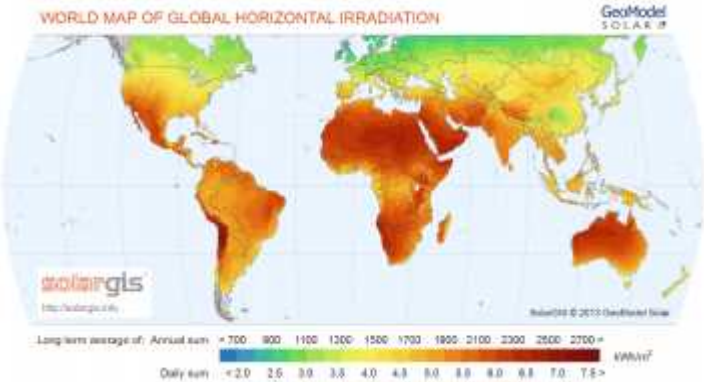
Malaysian Thematic Leaders will play the frontline role in dealing with DBKL.

WP 0 involves:-

- **3 DBKL inception, mid and final "science-policy outreach" workshops**
- **6 thematic capacity building workshops in Malaysia**
- **1 Training on outreach & commercialisation etc.**

Local Energy: solar panels

Workers atop an apartment building in Wuhan, China, install solar panels, whose growing popularity could help to cut greenhouse gas emissions. Credit: Kevin Frayer/Getty



Solargis.com

ENERGY · 04 JUNE 2018

Saving the climate without sacrifice

Modern trends such as car-sharing could help to limit warming.

Humanity can limit global warming and, at the same time, raise the quality of life around the world.

Energy Saving

Wuhan, China, *Nature* 2018

Local Energy: solar panels

Solar farms

climatenewsnetwork

Cooling Effect
Shading
Less water loss

Armstrong et. al. *ERL* 2016

Energy usage of high computing

Simpler, faster, localised models

Is staying online costing the Earth?

We must ensure that the growing opportunities afforded by data centres are not offset by their negative impact on climate change, write **Antoinette Sandbach** and **Daniel Zeichner**

If Britain is to prosper in the 21st century, it is through embracing the digital economy and building upon its thriving tech sector. However, many will be unaware of the considerable energy demands that are needed to sustain our digital infrastructure. The government and Labour have both indicated their support for expanding fibre optic broadband through the Grand Challenge for AI and Data and the Universal Service Obligation respectively. These aim to cement the UK's reputation as a world class centre for technology innovation. Alongside these digital ambitions sit our legally binding targets to reduce carbon dioxide emission. The question is, can we do both?

emails on your phone; many things we now take for granted, such as booking a train on the move, would become much harder. Data centres are therefore crucial to the effective running of our lives and to the economy.

Do data centres pose a risk to climate change?

There is plenty of concern about how much energy data centres could use in the near future and the risk to our climate. There have been calls for us to reduce our dependence on technology as a result. However, from the recent report we co-chaired – Is Staying Online Costing the Earth? – a more complex picture emerged.

> Too often data centres are inefficient small scale operations located in public and private sector organisations

Despite data centre workload being forecast to triple by 2030, energy demand is expected to grow by only 3%. This is due to continuing efficiency gains from servers and cooling equipment. It is also important to consider how this energy is generated: Google, Apple and Facebook have committed to sourcing 100% of their data centres energy from renewable sources. This is welcome news, but others must follow suit.

There is still much work to do. Too often data centres are inefficient small scale operations located in public and private sector organisations. In the public sector, 80% of data centres are small server rooms. We also need to gather better data on the private sector and how efficient their data centres are. Switching to cloud based or professionally run data centres can save both money and energy. So what is preventing the switch to more efficient data centres?

Next steps

There has been some innovative thinking in the public sector such as Crown Hosting Data Centres – a joint venture between the Cabinet Office and Ark Data Centres that offers more efficient and better value data centres to the UK public sector. However, the government needs to do more to drive through this change. Organisations in the public and private sector need to take advantage of these offers to enable growth that doesn't increase emissions.

We need to support transparent procurement practices that allow government and others to see the impact that their choices will have on the environment. Without this it is too easy to make the wrong choice.

The first step is a conversation, like the roundtable the APPGs on Climate Change and Data Analytics will hold this Wednesday. We know the answers to some of the difficult issues raised, so do industry, academia and charities. Our aim is to ensure the government appreciates the importance of energy efficient data centres and embraces the opportunity to make progress on our climate change targets.

Daniel Zeichner is Labour MP for Cambridge. **Antoinette Sandbach** is Conservative MP for Eddisbury.

MENU

nature climate change

Comment | Published: 29 October 2018

Bitcoin emissions alone could push global warming above 2°C

Camilo Mora, Randi L. Rollins, Katie Taladay, Michael B. Kantar, Mason K. Chock, Mio Shimada & Erik C. Franklin

Nature Climate Change **8**, 931–933 (2018) | Download Citation

Thank you for your attention and I look forward to our discussion!

Professor Julian Hunt

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