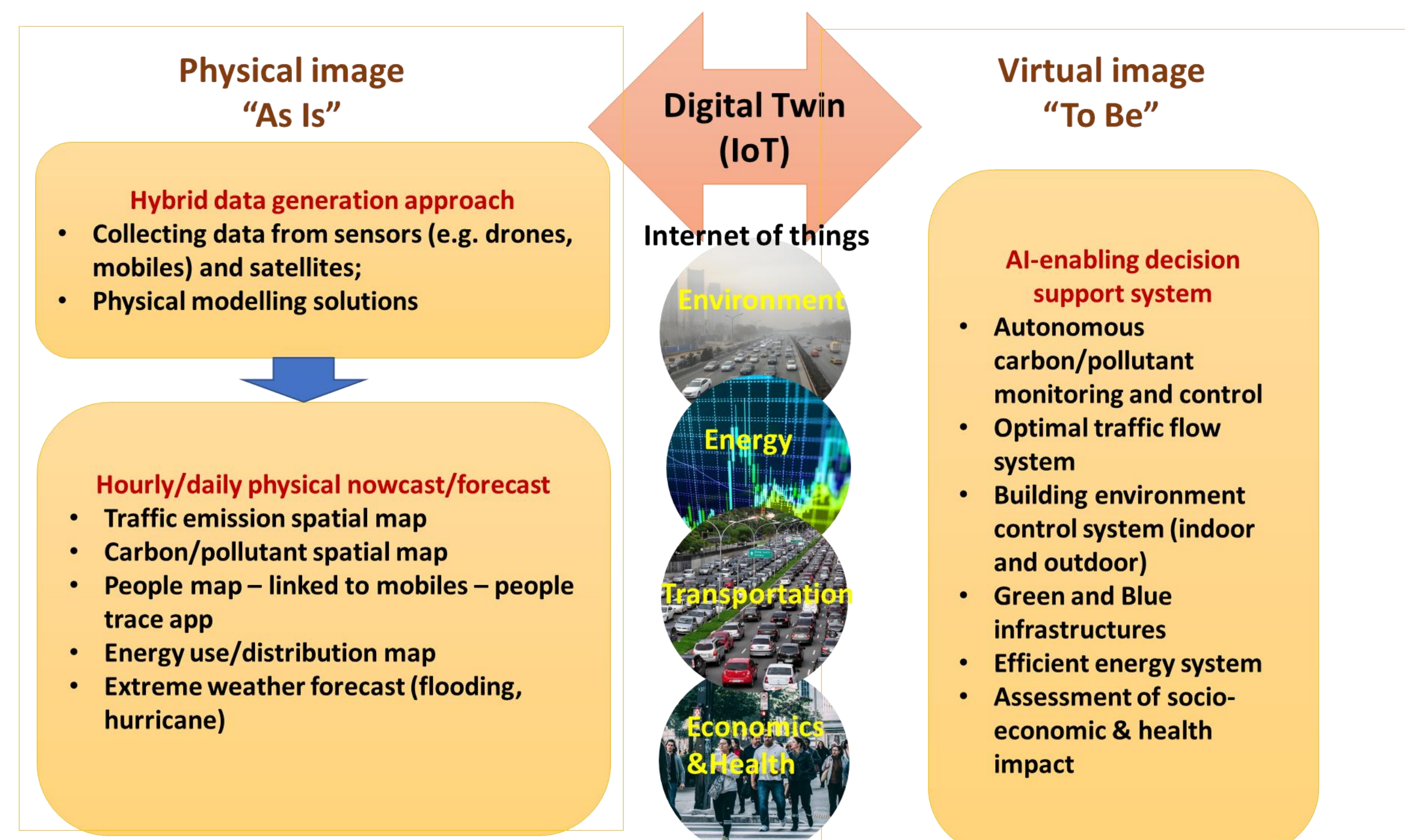# IMPERIAL

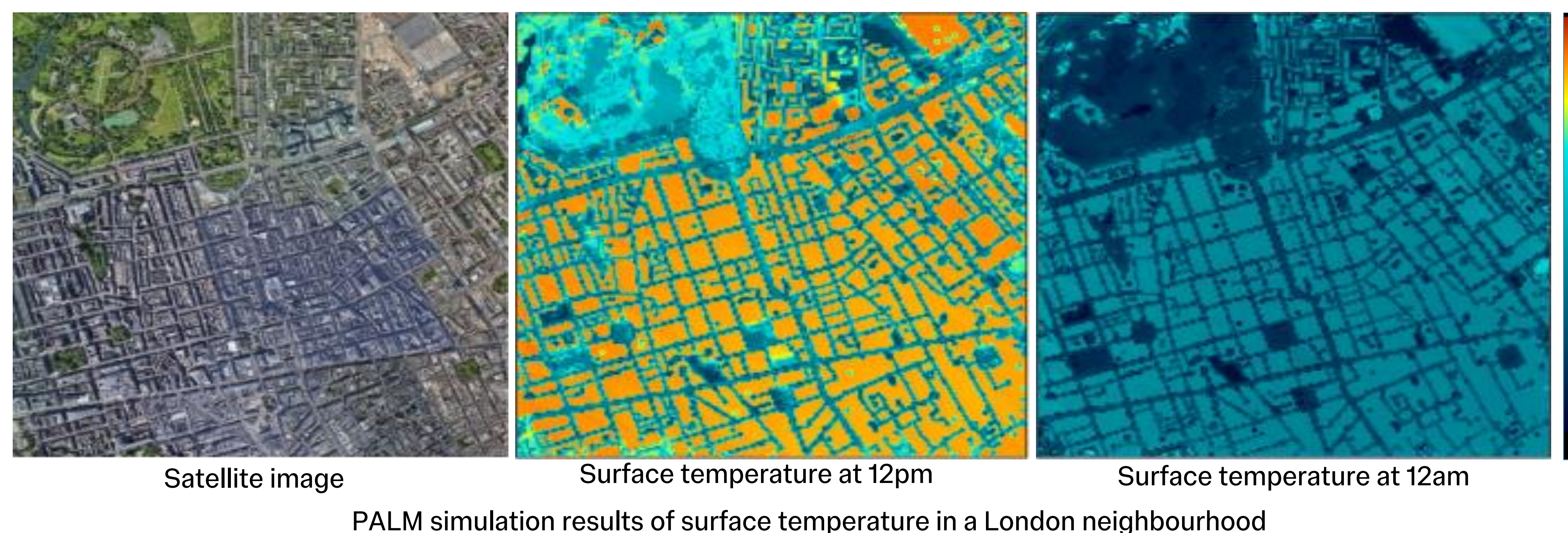# Hybrid AI and multiscale physical modelling for optimal urban decarbonisation combating climate change

Jie Zheng, Linfeng Li*, Judongyang Zhou, Fangxin Fang*
Imperial College London
Partners: Univ. of Surrey (Prof. Prashant Kumar), KAUST (Prof. Ibrahim Hoteit), Florida State Univ. (Prof. Navon), IAP & IUE, CAS, China (Profs. Zhu and Xiao), DIREK (A. Taba), ARUP (J. Hacker)

Challenges and solutions for urban planning in land-constrained sustainable cities

- Optimal ratio the areas of green-blue (G-B) infrastructures and buildings
- Incorporation of trees and greener roofs and walls
- Materials for buildings (low carbon emissions, cooling in Summer and heating isolation in Winter)
- Efficient energy use, and natural ventilation
- Advanced traffic and transportation monitoring and management systems for optimizing flow in densely populated areas
- Incorporate trees (types) along roadsides and medians for cooling and carbon absorption.
- Interaction of **health**, **economics**, **society**, and **environment -** a significant role in designing and managing a greener built environment, especially within limited spaces.
- Engagement of policy-maker, stakeholders, urban planers
- Use IoT, AI, and data analytics to monitor and optimize energy and traffic systems, thus reducing pollutant and carbon emissions – see Figure (Left)
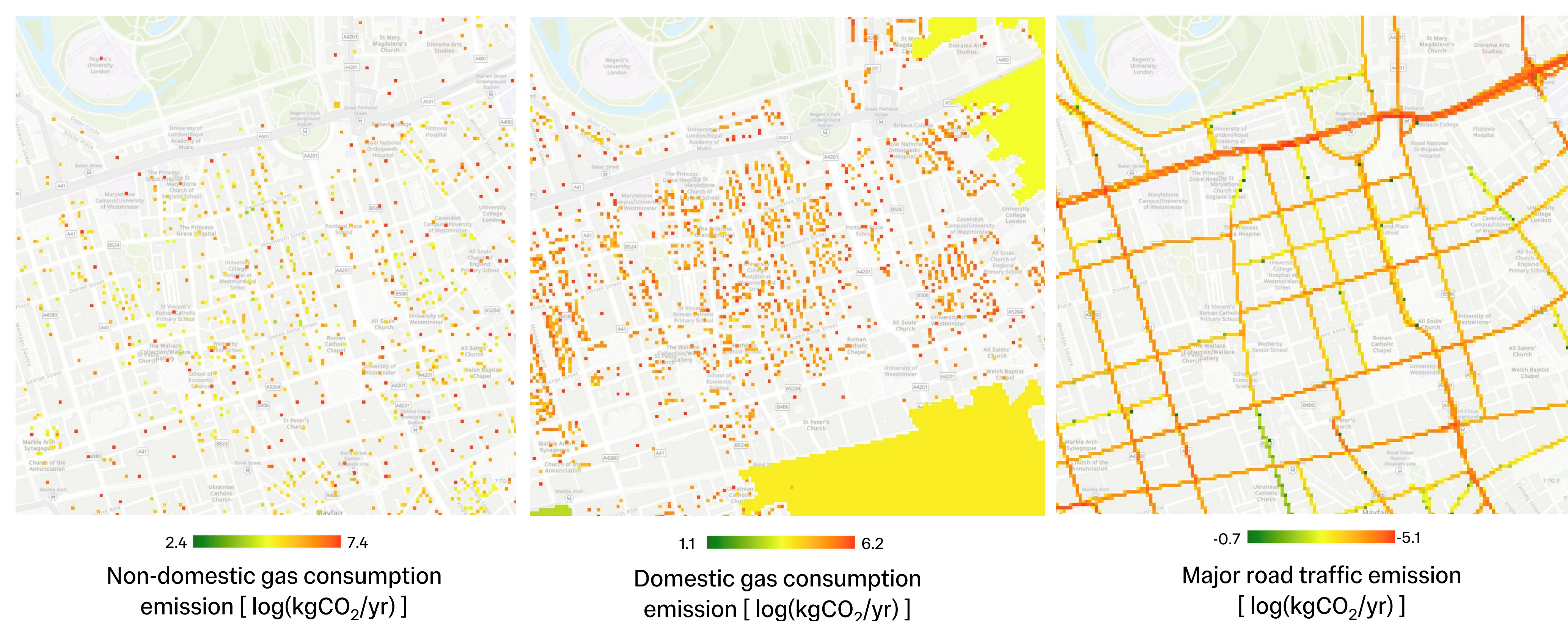

Multiscale urban environmental modelling

Satellite image | Surface temperature at 12pm | Surface temperature at 12am

PALM simulation results of surface temperature in a London neighbourhood
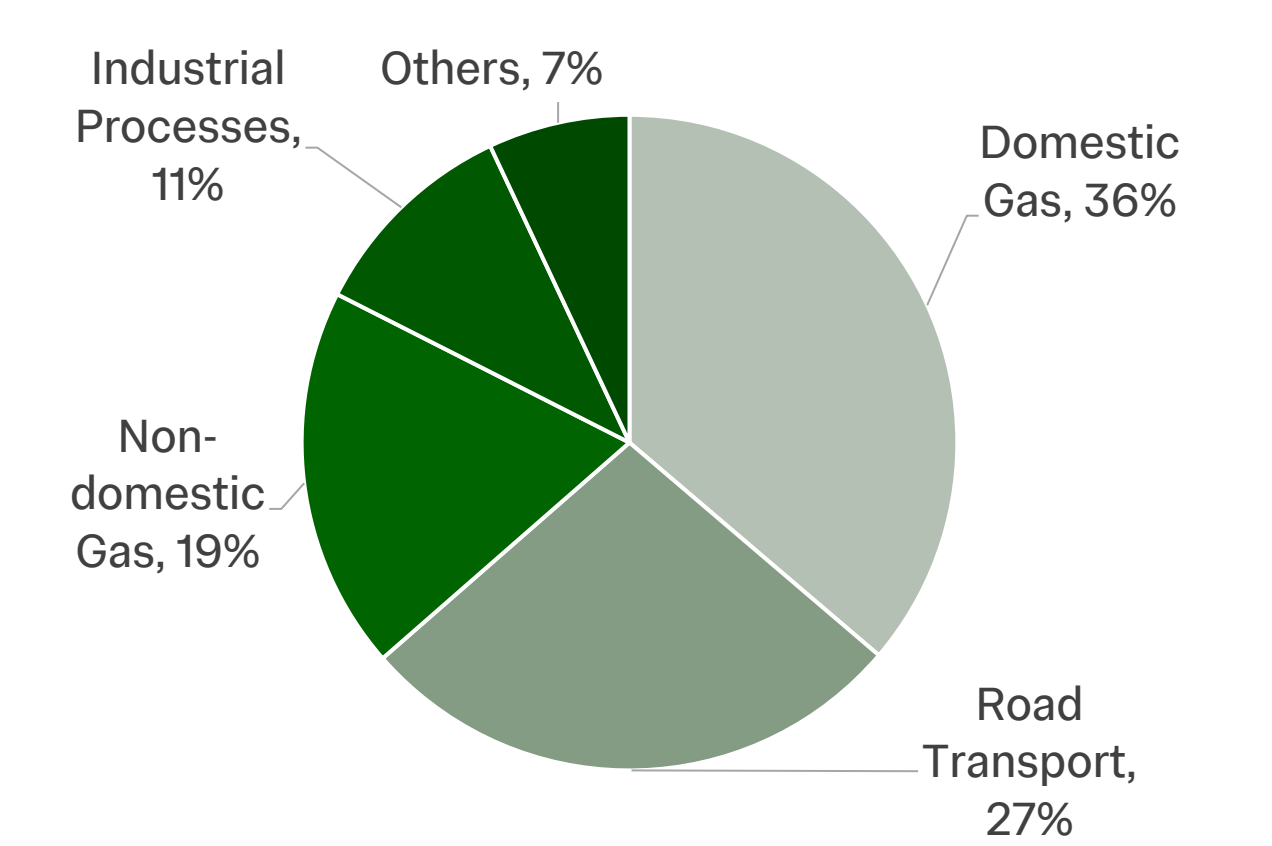
PALM is a large-eddy simulation model for atmospheric and environmental research. Here it is used for investigate the impact of green infrastructures on local climate and environment. Including:

- Radiative transfer model
- Land surface model
- Urban surface model
- Plant canopy model
- Prognostic equation for water vapour
- Periodic lateral boundary conditions with the clear-sky radiation scheme

High spatial resolution (10m by 10m) CO_2 emission grid map for London

Non-domestic gas consumption emission [log(kgCO$_2$/yr)] 2.4 — 7.4

Domestic gas consumption emission [log(kgCO$_2$/yr)] 1.1 — 6.2

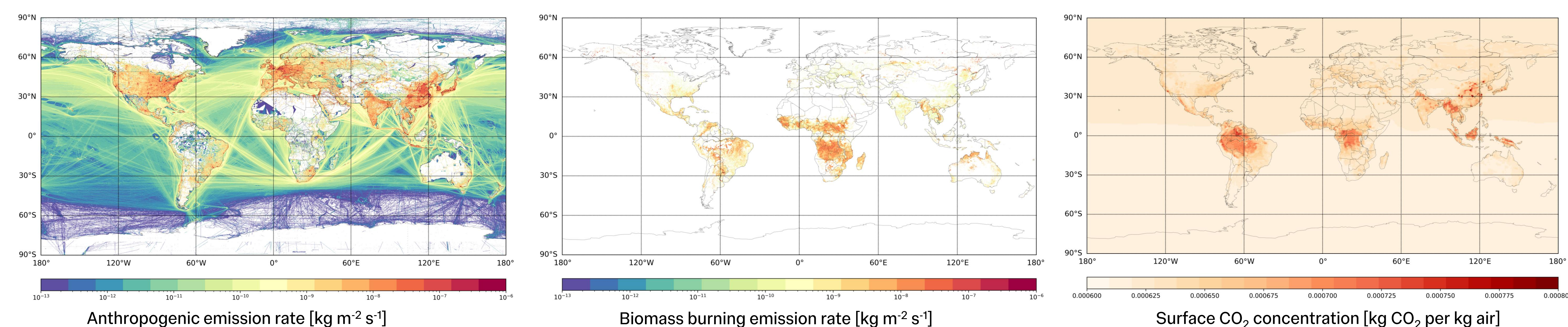Major road traffic emission [log(kgCO$_2$/yr)] -0.7 — -5.1

- Based on LAEI[1] inventory (1km by 1km), further disaggregate activity data at **high resolution** 10m by 10m.
- Domestic gas emission: distribute using EPC records
- Non-domestic gas emission: using non-domestic EPC and DEC records

Major emission sectors in Greater London [1]

Industrial Processes, 11% | Others, 7% | Domestic Gas, 36% | Non-domestic Gas, 19% | Road Transport, 27%

[1] London Atmospheric Emissions Inventory (LAEI) 2019, Greater London Authority

Global patterns and hotspots of CO_2 emissions and concentrations

Anthropogenic emission rate [kg m^{-2} s^{-1}]

Biomass burning emission rate [kg m^{-2} s^{-1}]

Surface CO_2 concentration [kg CO_2 per kg air]

Data Sources:
1. Copernicus Atmosphere Monitoring Service (CAMS), General Document on Emissions (April 2019, v7)
2. The CAMS global biomass burning emissions based on fire radiative power (GFAS)
3. The CAMS greenhouse gas reanalysis (EGG4) from 2003 to 2020

Imperial College London   * l.li20@imperial.ac.uk; f.fang@imperial.ac.uk

UKRI Engineering and Physical Sciences Research Council