IMPERIAL

EPSRC project: Urban environmental simulation in a high spatial resolution

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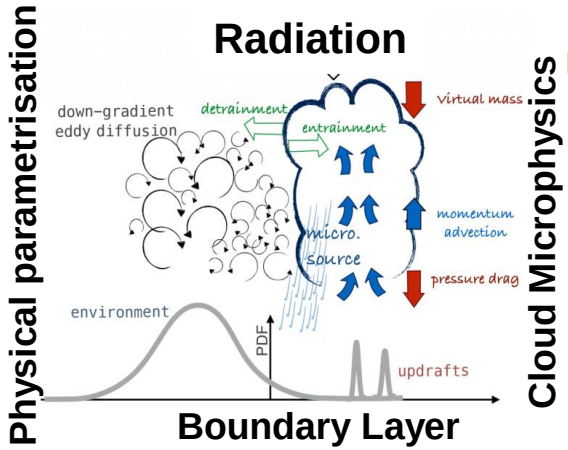
Complex physical processes

In Atmosphere and Urban Environments



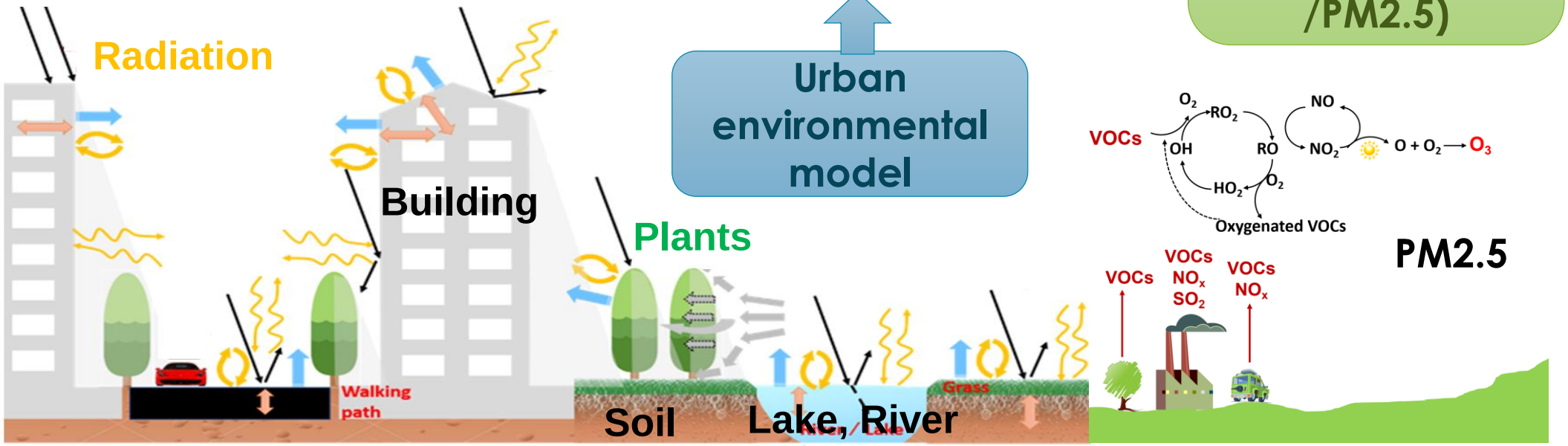
Turbulence, Heat and Mass Exchange

Regional atmospheric models

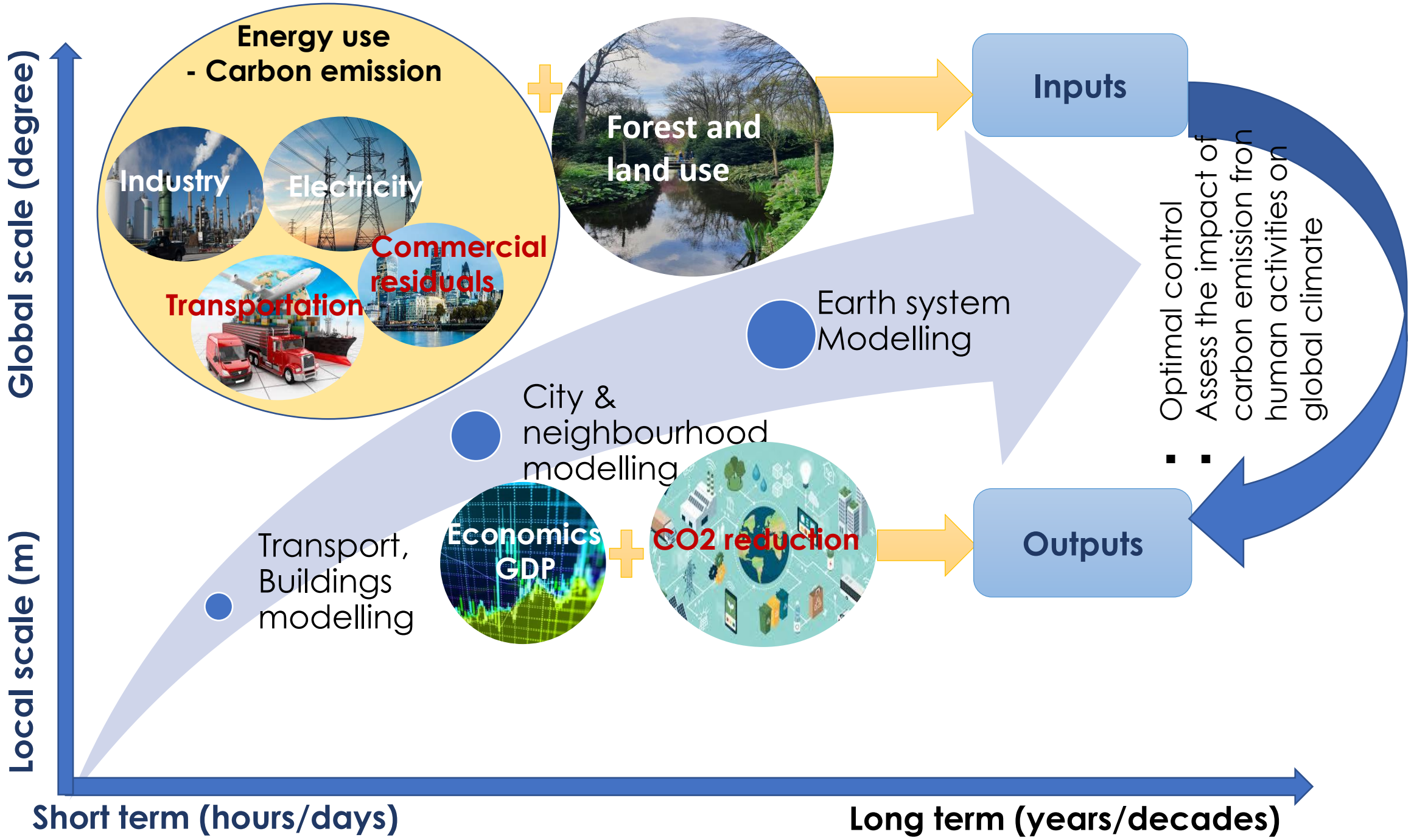
Multiscale dynamic core

Air quality model (chemical reactions /PM2.5)

Urban environmental model



PM2.5


Energy use
- Carbon emission
Industry
Electricity
Commercial residuals
Transportation
Forest and land use
Inputs
Earth system Modelling
City & neighbourhood modelling
Transport, Buildings modelling
Economics GDP
CO2 reduction
Outputs
Optimal control
Assess the impact of carbon emission from human activities on global climate
Global scale (degree)
Local scale (m)
Short term (hours/days)
Long term (years/decades)

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

Digital tools for Urban Environment Management:
Questions to be addressed

- How do anthropogenic carbon emissions affect local urban and global climate change?
- Which optimal GI-BI, buildings, transportation, and sustainable city designs provide maximum mitigation of carbon emissions & climate change?
- What is the trade-off between carbon reduction, energy use and economics?
- How can detailed multi-scale models provide efficient and accurate prediction of carbon emissions and their impact on climate change?
- What are the feedbacks of the urban carbon contribution to global climate? (Assess tge improvement of global climate after carbon reduction via optimal management of infrastructures)

Physical image
"As Is"

Hybrid data generation approach

- Collecting data from sensors (e.g. drones, mobiles) and satellites;
- Physical modelling solutions

Hourly/daily physical nowcast/forecast

- Traffic emission spatial map
- Carbon/pollutant spatial map
- People map – linked to mobiles – people trace app
- Energy use/distribution map
- Extreme weather forecast (flooding, hurricane)

Digital Twin (IoT)

Internet of things

Virtual image
"To Be"

AI-enabling decision support system

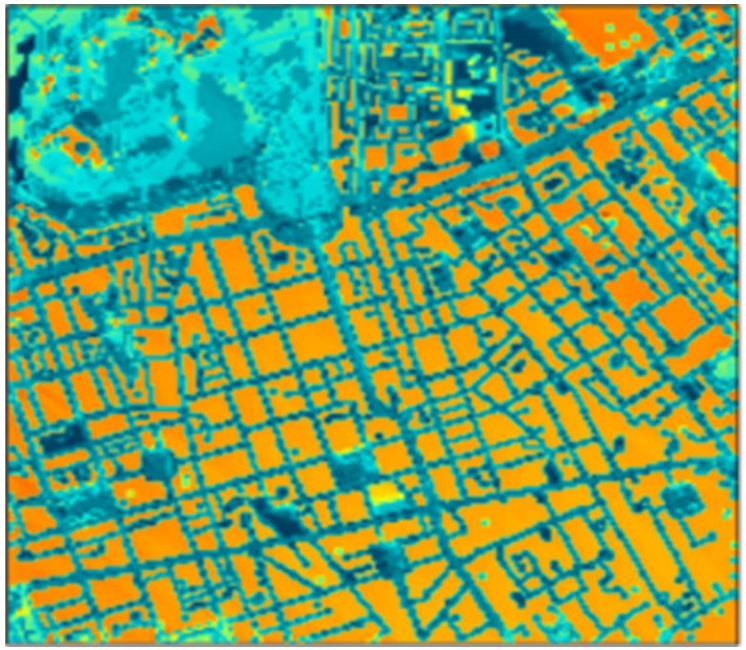
- Autonomous carbon/pollutant monitoring and control
- Optimal traffic flow system
- Building environment control system (indoor and outdoor)
- Green and Blue infrastructures
- Efficient energy system
- Assessment of socio-economic & health impact

Multiscale physical simulations (J. Zheng)

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

Satellite image



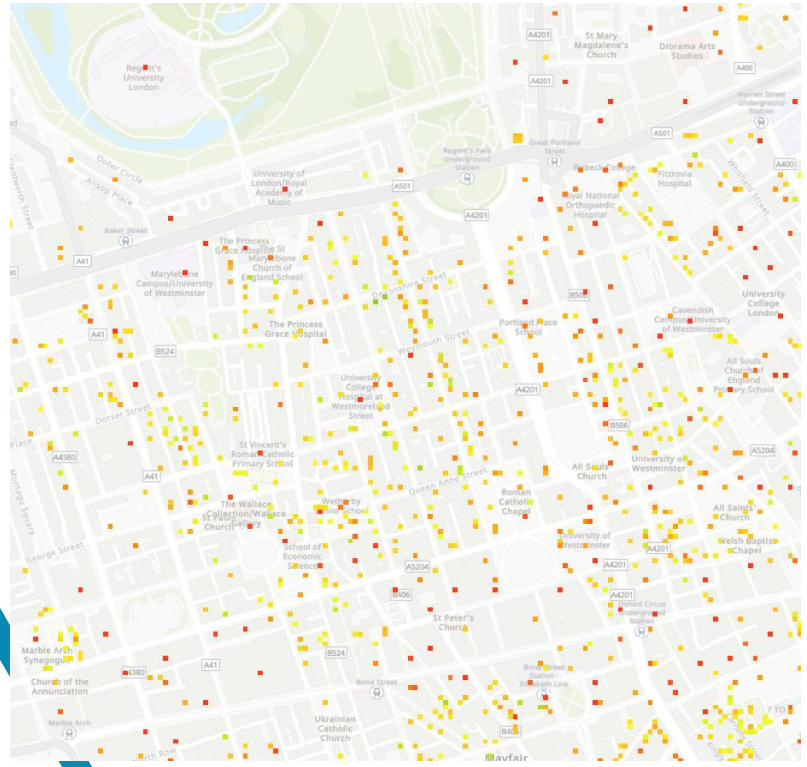
Surface temperature at 12pm

Surface temperature at 12am

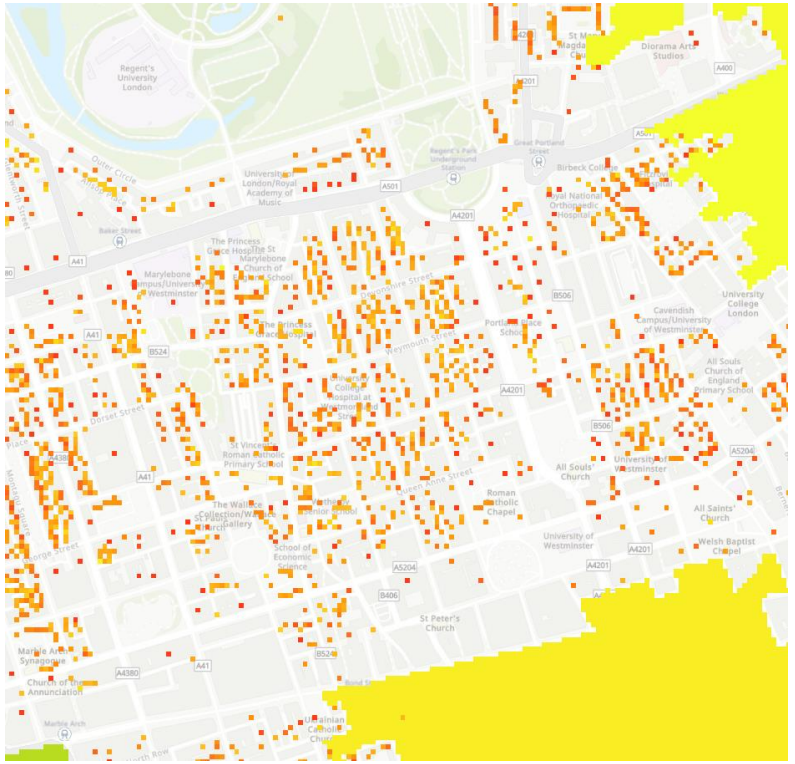
CO_2 emission grid map for London (L. Li)

High spatial resolution (10m by 10m)

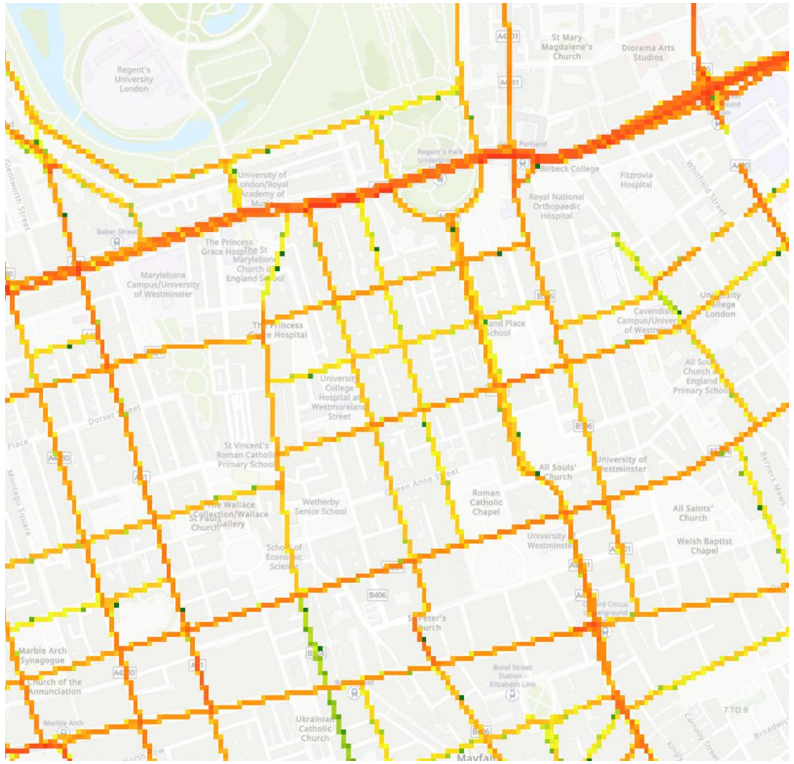
- Based on LAEI[1] inventory (1km by 1km), further disaggregate activity data at **high resolution** 10m by 10m.
- Domestic gas emission: distribute using EPC records
- Non-domestic gas emission: using non-domestic EPC and DEC records



Non-domestic gas consumption emission [log($kgCO_2$/yr)]

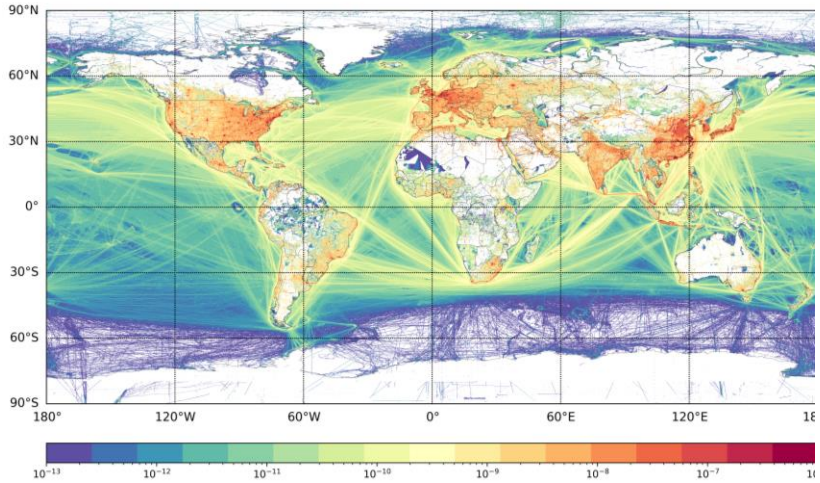


Domestic gas consumption emission [log($kgCO_2$/yr)]

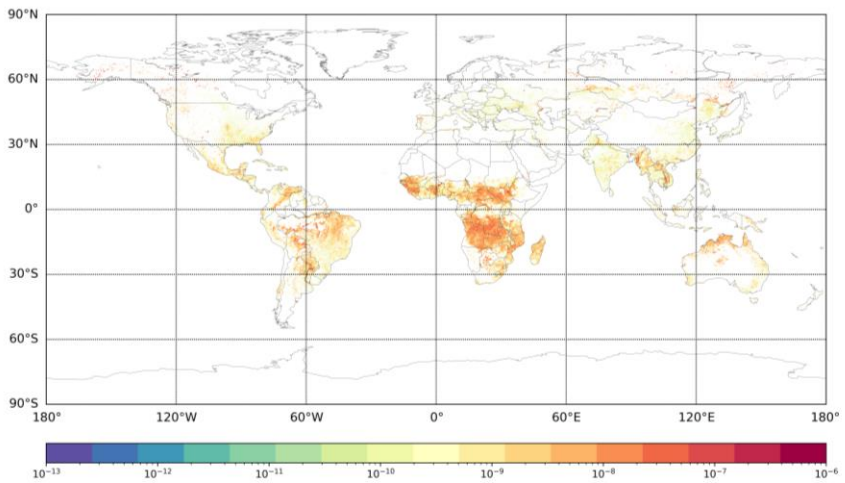


Major road traffic emission [log($kgCO_2$/yr)]

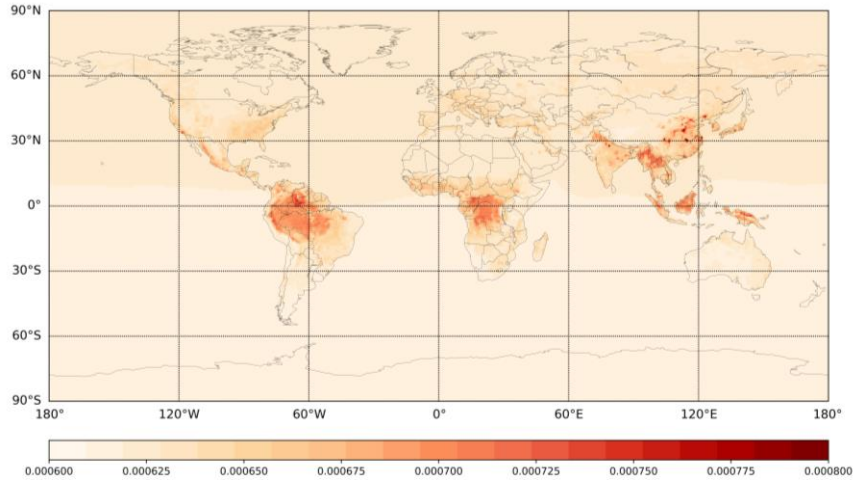
Global patterns and hotspots of CO_2 emissions and concentrations (J. Zhou)



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

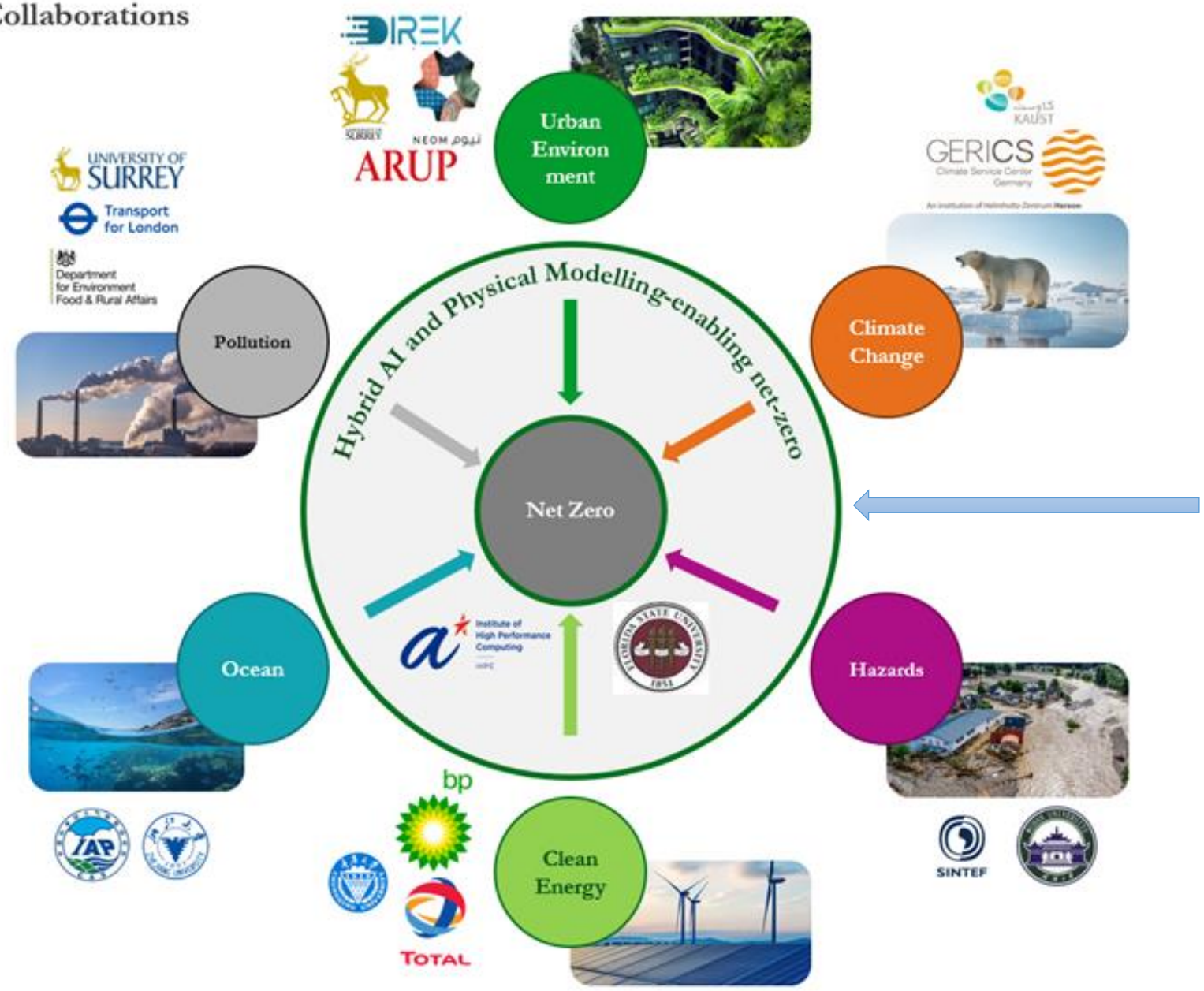


Biomass burning emission rate
[kg m^{-2} s^{-1}]



Surface CO_2 concentration
[kg CO_2 per kg air]

Collaborations



Internal collaboration

ESE;
Environmental research group;
Centre for environmental policy;
Civil and Environmental Engineering;
Physics Atmosphere;
Data Science Engineering;
I-X;
Grantham institute;
ICT

Project Website

Thanks!

SCAN ME

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