Climate change and cities:
Integrated assessment of impacts, adaptation and mitigation

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• **Focal points of consumption and emissions**
  – 50% global population
  – 60-80% global GHG emissions

• **Concentrations of vulnerability to chronic climate stress and extremes**
  – Flooding
  – Water scarcity
  – Heat, air quality

• **Complex adaptive systems that**
  – Exhibit strong path-dependence
  – Are embedded in super-systems (national, regional, global)
  – Vary on a wide range of time scales
  – Respond in unforeseen ways to planning endeavours

• **Increasingly important actors in setting the climate agenda** (Cities for Climate Protection, C40, Clinton Climate Initiative, ICLEI, Nottingham Declaration etc.)
Transformation of urban systems will require:

- Much improved understanding of the mechanisms of interaction in urban function, via:
  - Land use
  - Transport
  - Resource flows (energy, water, nutrients)
  - Building form and function
  - Urban climate
  - Information networks

- Recognition of the time scales of change and the legacy of past decisions (planning, infrastructure, buildings)

- Development of collective understanding of urban function and collaborative platforms for exploration of transition strategies

- Motivation and leadership
Adaptive management in Earth systems

**Decision Processes**
- Participative option generation
- Evidence-based options appraisal

**Earth System Modelling**
- Integrating hard and soft systems

**Earth System Observation**

**Interventions in Earth Systems**
- Technologies for mitigation and adaptation
- Economic, social and political processes

Co-evolutionary human, technological and natural systems
A city-scale integrated assessment that:

- Address emissions, impacts, adaptation and mitigation
- Works on the timescales of major planning and infrastructure decisions i.e. up to 2100
- Is based upon coherent national and regional economic, demographic and climate scenarios
- Is coupled with spatially explicit simulations of land use in order to understand key vulnerabilities (e.g. flood risk) and the effects of spatial planning decisions
- Includes the functioning of engineering infrastructure systems in a physically realistic way
- Allows portfolios of adaptation/mitigation strategies to be explored – likely to be more effective than unilateral action
London

- Most populous and one of largest urban areas in the European Union: 1,584km²
- Population in decline between 1939-89, but ‘resurging’ and now 7.2million
- Relatively low density for EU (~2/3 population live in the suburbs)
- Governed by the Greater London Authority (est. 2000)
- Drivers for change:
  - Economics
  - Population and demography
  - Technology
  - Environmental attitudes
  - Landuse and transport planning (eg. 2012 Olympics, Thames Gateway)
  - Governance
  - Relationship with rest of UK
Overview of assessment system

Economic and demographic scenarios
Overview of assessment system

Climate scenarios

Economic and demographic scenarios
Overview of assessment system

Economic and demographic scenarios

Climate scenarios

MDM regional economics model

Employment in thousands for London aggregated in 8 sectors

Population (thousands)

Po

2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100

Year

MDM regional economics model
Overview of assessment system

- Economic and demographic scenarios
- MDM regional economics model
- Employment, population and land use model

Population and land use model

Climate scenarios
Overview of assessment system

- Economic and demographic scenarios
  - MDM regional economics model
  - Employment, population and land use model
    - Impacts assessment:
      - Flooding
      - Water resources
      - Heat

Climate scenarios
Overview of assessment system

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Employment, population and land use model

Impacts assessment:
- Flooding
- Water resources
- Heat

Emissions accounting:
- Energy (GRIP)
- Personal travel
- Freight transport

Tyndall Centre
for Climate Change Research

Newcastle University
Overview of assessment system

**Economic and demographic scenarios**

**MDM regional economics model**

**Impacts assessment:**
- Flooding
- Water resources
- Heat

**Testing of policy options**

**Climate scenarios**

**Emissions accounting:**
- Energy (GRIP)
  - Personal travel
  - Freight transport

**Tyndall Centre**

for Climate Change Research

**Environment Agency**

**Mayor of London**

**Transport for London**

**Thames Water**
Water resources

- **maximum permitted availability**
- availability for simulated rainfall (present day climate)
- medium high emissions, 2080s
- medium high emissions, 2050s
- medium high emissions, 2020s

**Graph Details:**
- X-axis: Number of days available for abstraction
- Y-axis: Probability of non-exceedance
- Graphs for different scenarios and years are shown.

**Cities:**
- Adelaide, Australia
- Dallas, USA
- Istanbul, Turkey
- Jakarta, Indonesia
- London, England
- Los Angeles, USA
- Rome, Italy
- Kuala Lumpur, Malaysia
Water resources

- Maximum permitted availability
- Availability for simulated rainfall (present day climate)
- Medium high emissions, 2080s
- Medium high emissions, 2050s
- Medium high emissions, 2020s

Graph showing:
- Desalination capacity (Mm³)
- Total reservoir size (Mm³)
- Global CO₂ concentration (ppm)
- Probability
- Number of days available for abstraction

Cities included:
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- Dallas, USA
- Istanbul, Turkey
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- London, England
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Modal shift, Hydrogen infrastructure and carbon trading

Accounts for CC Action Plan and TfLs long term investment strategy

<table>
<thead>
<tr>
<th>Year</th>
<th>% change from baseline</th>
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<tbody>
<tr>
<td>2010</td>
<td>~10%</td>
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<tr>
<td>2015</td>
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<tr>
<td>2020</td>
<td>~0%</td>
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</tbody>
</table>
Modal shift, Hydrogen infrastructure and carbon trading
Greenhouse gas emissions

Emissions (kT) Total2005

- Household
- Non household
- Total

Year

Emissions (kT)

2000 2010 2020 2030 2040 2050

0 7,500 15,000

0-20 20-40 40-80 80-160 160-320 320-640 ≥640

Emissions of greenhouse gases as shown in the map and graph.
Economic model selection

Please select an economic scenario from the drop down menu.

There are 15 economic timeseries outputs from the MDM-IIK model.

A simple model that assumes a constant growth rate (measured in percentage annual change in overall employment) also be setup. This can be used for sensitivity testing of economic conditions than the MDM scenarios.

- MDM Scenarios
- Model
Economic model selection

Please select an economic scenario from the drop down menu.

There are 15 economic timeseries outputs from the MDM-IK model.

A simple model that assumes a constant growth rate (measured in percentage annual change in overall employment) can also be setup. This can be used to test the model over a wider range of economic conditions than the MDM scenarios.

MDM Scenarios

Model
• Systems analysis at city-scale

• Scenarios of long term regional economic, demographic and land use change

• Analysis of climate impacts, based on high resolution climate and socio-economic scenarios

• Scenarios of emissions from various sectors

• Insights into the potential effects of:
  – Land use planning policies and transport infrastructure on land use change and climate impacts (so far flooding, then heat)
  – Adaptation investment decisions (flood defence, water resources)
  – Energy and transport policies on emissions

• Long term look
  – Identify ‘lock-ins’
  – Work on time horizon of major infrastructure decisions
Some remaining questions

1. How far is far enough in tracking down consistency, interactions and feedbacks?

2. How can we estimate and communicate uncertainties?

3. How transferable are our insights and methods to other cities worldwide?

4. How can we build a global coalition of researchers and practitioners equipped to address these problems?

5. How can we best engage stakeholders and inform decision making?

Building bridges

- Quantifying impacts
- Emissions projections
- Testing multiple land use/adaptation/mitigation scenarios
- City scale overview that integrates across sectors traditionally analysed independently
- Detailed design will use tailored models

- London Plan is very broad - we can’t inform it all!
There is something between the gross specialised values of the mere practical man, and the thin specialised values of the mere scholar.

Both types have missed something; and if you add together the two sets of values, you do not obtain the missing elements.

What is wanted is an appreciation of the infinite variety of vivid values achieved by an organism in its proper environment.

When you understand all about the sun and all about the atmosphere and all about the rotation of the earth, you may still miss the radiance of the sunset.

Alfred North Whitehead 1925
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The Tyndall Cities Programme team:

Newcastle: Jim Hall, Richard Dawson, Clare Walsh, Stuart Barr, Ali Ford
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Cambridge: Terry Barker, Athanasios Dagoumas
UEA: Clare Goodess
UCL: Mike Batty, Steve Evans
Leeds: Miles Tight, Helen Harwatt
Loughborough: Abigail Bristow, Alberto Zanni

With thanks as well to: Lucy Manning & Tibebu Bekele (Newcastle)
- **Interdisciplinary** – different disciplines ‘embracing’ an evolving blend of approaches, methods, etc.

- Not likely to be easy: reversing years of increasingly focused disciplines

- Not always state of the art for each discipline
  - Often a synthesis of research
  - Simplification
  - BUT there is an inter-disciplinary “science” in its own right

- Challenges
  - Language (Jargon, acronyms) (Prejudice?)
  - Philosophy (Numbers vs. Words vs. Pictures)

- Need mechanisms (and money) to support real ID activity
  - Secondments; ‘Integrating’ researchers
  - Social events – never undervalue a beer or coffee
  - Long process – continual dialogue

- A lot of what is labelled “ID” is not ID
  - Social science with some statistics on the end; engineering with a social scientist tagged on at the end
  - Involve all parties (inc. Stakeholders) at the start
  - BUT do need to identify shared vision/goal/focus to avoid stalling

- **BUT THE WORLD IS NOT DISCIPLINARY**
  - To understand the big questions we need to bridge the “gaps”
  - Policy makers will make decisions regardless on big issues - ID research can provide the evidence basis