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Centre for Earth Systems Engineering Research

School of Civil Engineering & Geosciences

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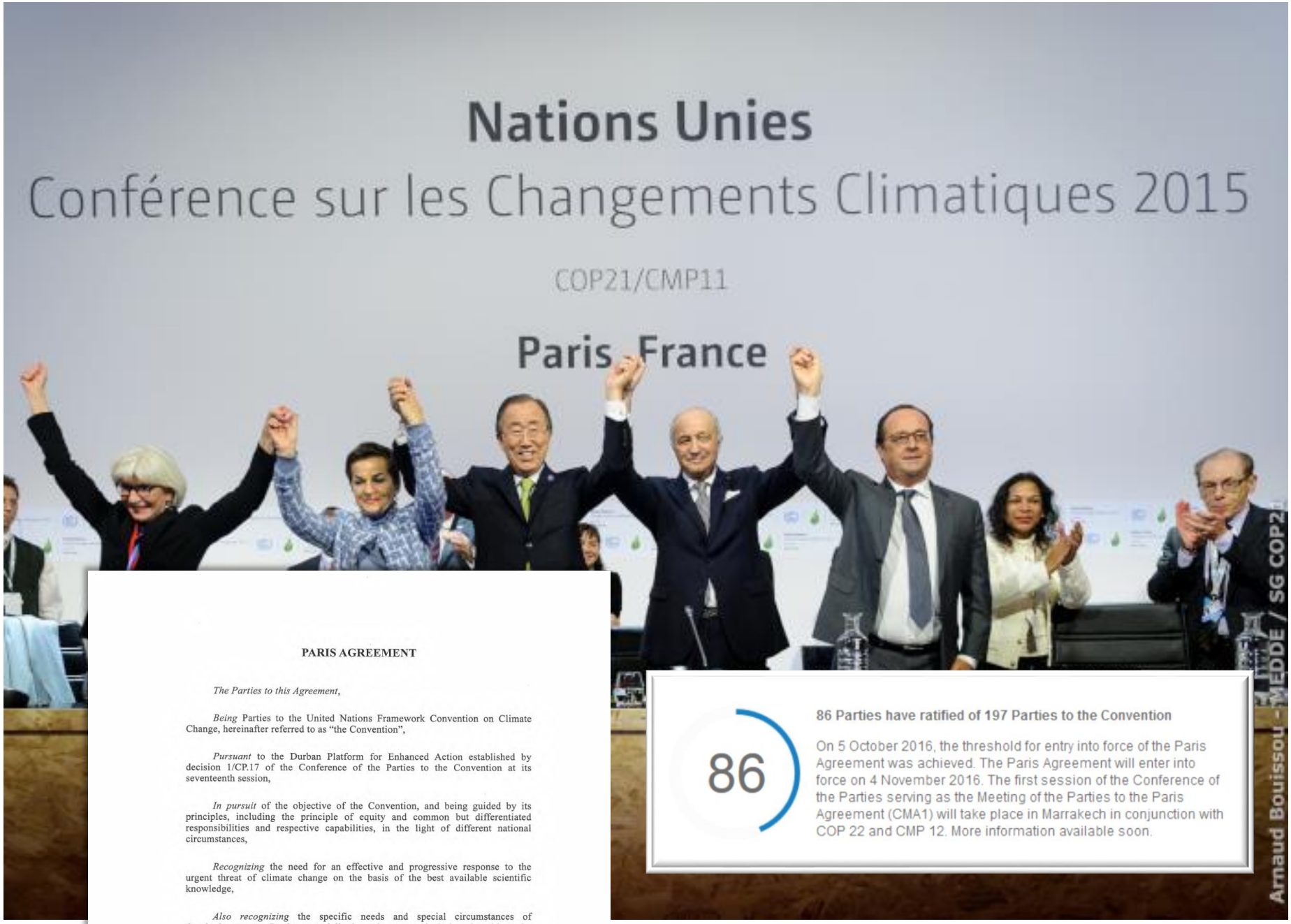
Climate Change and Transport Land-use,

A Case Study in London

Alistair Ford, Newcastle University

Symposium for the Integration of Land-Use and Transport Models
2nd – 4th November, 2016



PARIS AGREEMENT

The Parties to this Agreement,

Being Parties to the United Nations Framework Convention on Climate Change, hereinafter referred to as "the Convention",

Pursuant to the Durban Platform for Enhanced Action established by decision 1/CP.17 of the Conference of the Parties to the Convention at its seventeenth session,

In pursuit of the objective of the Convention, and being guided by its principles, including the principle of equity and common but differentiated responsibilities and respective capabilities, in the light of different national circumstances,

Recognizing the need for an effective and progressive response to the urgent threat of climate change on the basis of the best available scientific knowledge,

Also recognizing the specific needs and special circumstances of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change, as provided for in the Convention,

Taking full account of the specific needs and special situations of the least developed countries with regard to funding and transfer of technology,

86

86 Parties have ratified of 197 Parties to the Convention

On 5 October 2016, the threshold for entry into force of the Paris Agreement was achieved. The Paris Agreement will enter into force on 4 November 2016. The first session of the Conference of the Parties serving as the Meeting of the Parties to the Paris Agreement (CMA1) will take place in Marrakech in conjunction with COP 22 and CMP 12. More information available soon.

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Paris Agreement

"Limit global temperature rise this century **well below 2 degrees Celsius** above pre-industrial levels and to **pursue efforts to limit** the temperature increase even further **to 1.5 degrees Celsius**."

- **BUT:** little action in last 15 years, emissions now 60% higher than in 1990, CO_2 at highest levels in 800,000 years.
- 5 to 8 years of current global emissions will use up 1.5° budget.
- Limiting warming to 2° will require unprecedented change.

- "For a successful policy, reality must take precedence over public relations, as nature cannot be fooled"

Richard Feynman

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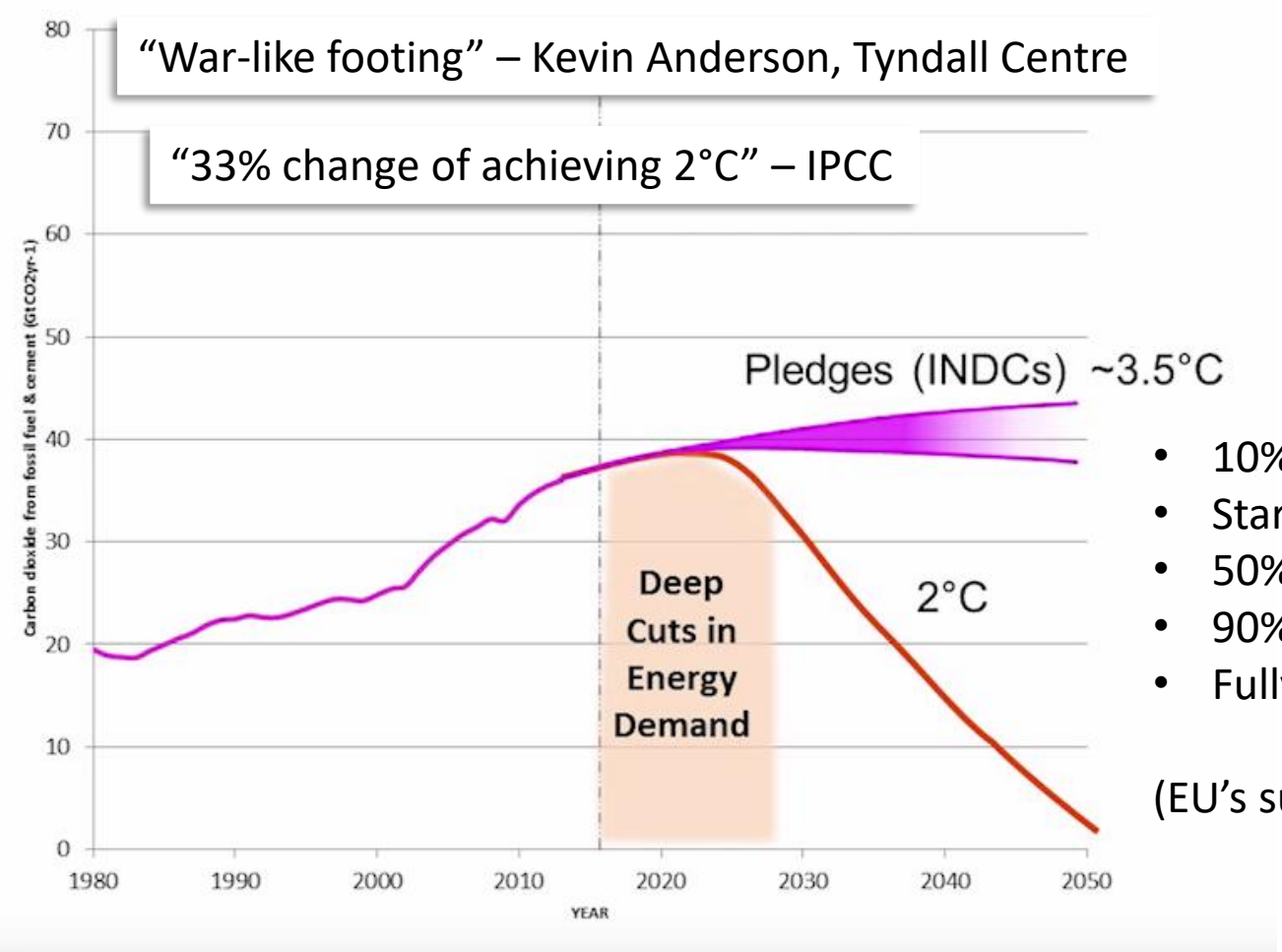
Implications



- 10% reduction every year
- Starting **now**!
- 50% reduction by 2020
- 90% reduction by 2030
- Fully-decarbonise by 2035

(EU's submission to Paris Agg: 40% by 2030)

Courtesy Kevin Anderson, Tyndall Centre

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Paris City Hall Declaration

Over 1000 city leaders pledged to:

Advance and exceed the expected goals of the 2015 Paris Agreement to be reached at COP 21 to the full extent of our authorities;

Produce and implement participatory resilience strategies and action plans to adapt to the rising incidence of climate-related hazards by 2020;

Deliver up to 3.7 gigatons of urban greenhouse gas emissions reductions annually by 2030, the equivalent of up to 30% of the difference between current national commitments and the 2 degree emissions reduction pathway identified by the scientific community;

Support ambitious long-term climate goals such as a transition to 100% renewable energy in our communities, or a 80% greenhouse gas emissions reduction by 2050;

Engage in partnerships among ourselves and with global organizations, national governments, the private sector, and civil society to enhance cooperation and capacity-building programs, scale-up climate change solutions, develop metrics and promote innovative finance mechanisms and investments in low-emission projects across the world.

Cities: the problem…and solution

- **Cities need to adapt**, but beyond 3 degrees of global warming adaptation becomes questionable and uncertain
- Cities play an important role in the **sustainability transition**
- Certain cities are more efficient than others in terms of emissions
- Cities are perfect places to generate **co-benefits**
- Cost assessments should make clear where we have **limits**
- Knowledge about gross effects are needed for global policy making, while on the ground more **detailed information is needed for more concrete policy-making**
- Land-use and transportation are key to the post-Paris transition in cities

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Adaptation vs Mitigation

Response	Potential benefit	Potential negative impact
Air conditioning	Reduce heat stress	Increase energy needs and emissions
Densification of cities	Reduce public transport emissions	Increase urban heat island intensity and exposure to grater noise pollution
Desalination plants	Secure water supply	Increase greenhouse gas emissions
Irrigation	Supplying water for food	Salinisation of soil, degradation of wetlands,
Biofuels for transport and energy	Reduce GHG emissons	Encourage deforestation; replace food crops raising food prices; can increase local air quality pollutants such as NO_x
Catalytic convertors	Improve air quality	Large scale mining and international resource movements
Cavity wall insulation	Reduce GHG emissions	Increase damages from a flood event
Raise flood defence	Reduce flood frequency	Encourage more development (positive feedbacks)
Pesticides	Control vector borne disease	Impact on human health, increased insect resistance
Conservation areas	Preserve biodiversity and ecosystems	Loss of community livelihoods
Insurance/disaster relief	Spread the risk from high-impact events	Reduce longer term incentive to adapt
Traffic bypasses or radial routes	Displaces traffic from city centre, improving air quality and reducing noise	Can increase congestion and journey times (consequently overall greenhouse gas emissions)
Vehicle user charging	Discourage vehicle use to reduce greenhouse gas emissions	Lead to greater social inequality

Adapted from: Dawson (2011) Potential pitfalls on the pathway to sustainable cities … and how to avoid them, *Carbon Management*, Vol 2(2)

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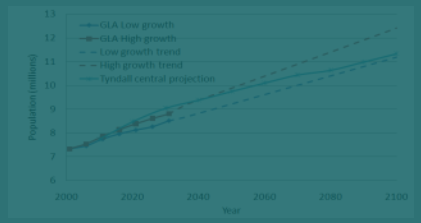
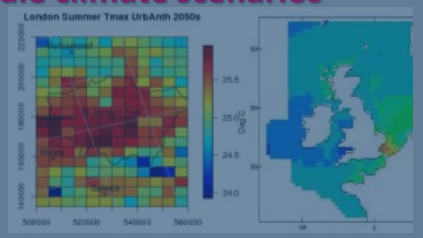
Mitigation Adaptation

Socio-economic scenarios



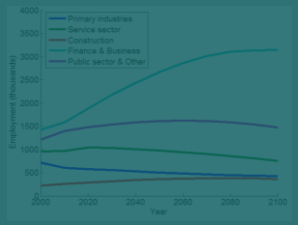
City-scale climate scenarios

- Temperature
- Precipitation
- Sea level rise
- Storm surge



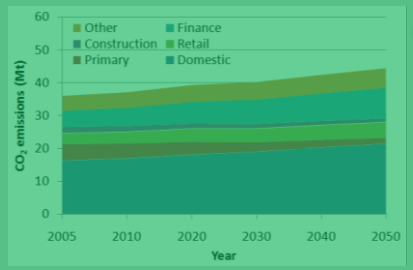
Regional economy

- Dynamic resource interactions between sectors
- Specialist energy sector module



Greenhouse gas emissions

- Multi-sectoral emissions accounting
- Detailed sub-modules for transport (personal and freight)



Analysis of city-scale energy policies

Land use transport model

- Employment
- Multi-modal transport
- Developed land cover
- Population
- Planning constraints and attractors

Climate impacts and adaptation

- Flooding
- Drought
- Urban heat

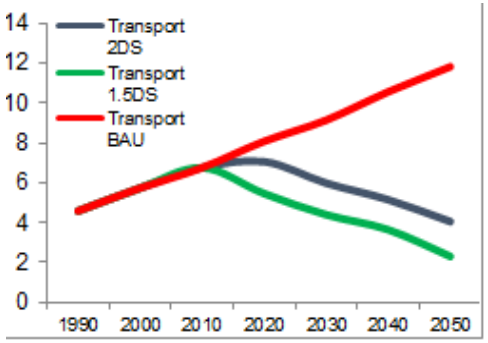
Test adaptation options

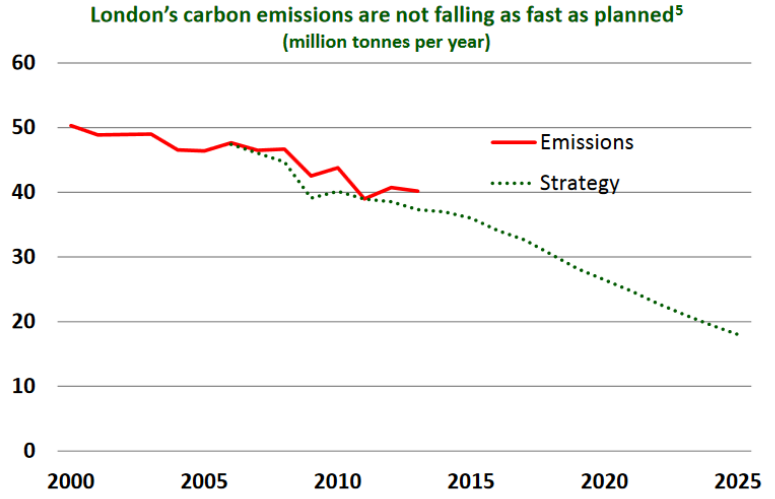
Testing of policy options

- Working with key London stakeholders

Mitigation: reducing energy demand

- London target: 60% reduction by 2025
- Transport emissions (currently 22% of total)
  - 48% reduction by 2025
  - Vehicles and control systems
  - Passenger and freight (train 76%↓ vs lorry)
  - Technology vs behaviour
  - Urban form
- Building emissions
  - Residential (36%)
  - Commercial
  - Industrial } (42%)





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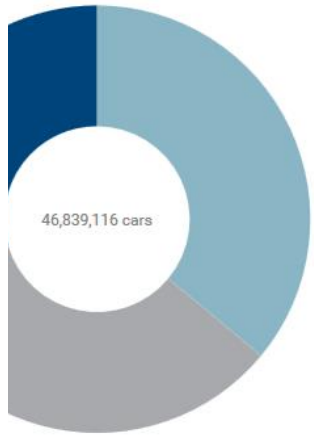
	Total	Petrol	Diesel	Alternative fuel
Belgium	490 369	169 665	319 863	841
Bulgaria	199 963	:	:	:
Czech Republic	164 627	:	:	:
Denmark	:	:		:
Germany	2 952 431	1 502 784		46 534
Estonia	19 690	12 20		137
Ireland	74 960			640
Greece	:			:
Spain (2)	710 6			192
France	1			975
Croatia				72
Italy				
Cyprus				
Latvia				11
Lithuania (3)				534
Luxembourg (2)				
Hungary			343	1 917
Malta			5 267	27
Ne			:	:
A		36 689	181 061	1 285
P		449 741	468 097	69 971
Por		02	:	:
Rom	279 740	141 921	136 673	1 146
Slovel	51 968	23 942	28 016	10
Slovaki	113 876	:	:	:
Finland	103 450	64 194	38 697	2 000
Sweden	292 162	108 067	176 485	7 610
United King	1 907 411	924 509	958 536	24 366
Iceland	:	:	:	:
Liechtenstein	1 920	1 041	858	21
Norway	176 019	67 701	97 464	10 854
Switzerland (2)	334 000	200 600	125 000	8 600
Montenegro	:	:	:	:
The former Yugoslav Republic of Macedonia (2)	32 870	:	:	:
Serbia (5)	28 951	18 393	7 364	3 194
Turkey	654 905	256 506	383 904	14 495

Total decarbonisation by 2035%?!

re then 10 years



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Aspirations vs Reality

ANOTHER £350m A1 improvement scheme revealed - this time near Birtley

Proposed layout

The environmental costs of Heathrow expansion

Matt McGrath
Environment correspondent

25 October 2016 | Science & Environment

There are environmental concerns about noise, air pollution and climate change

Chancellor signals boost for roads and railways but warns on 'unhealthy' fiscal position

"Often it is modest, rapidly deliverable investments that can have the most immediate impact, particularly on the road network, but also in some places on the rail network."

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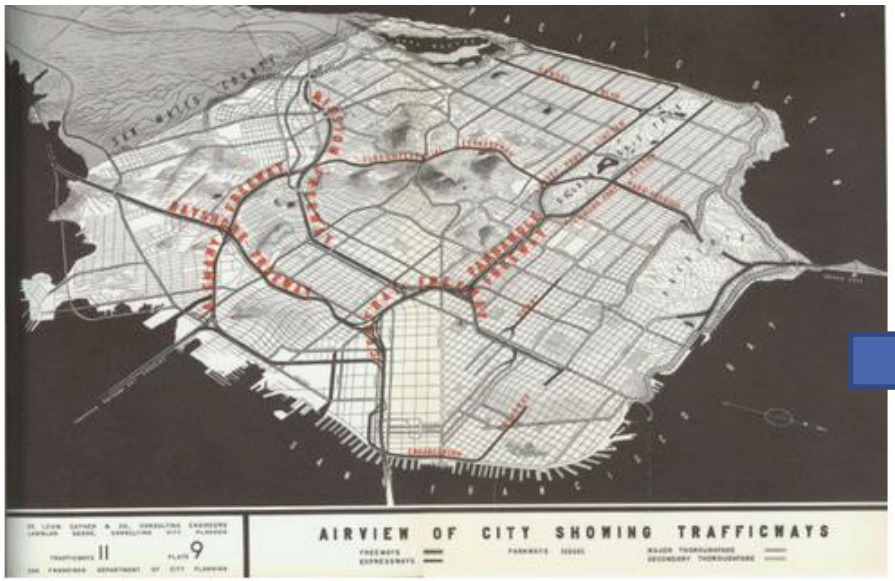
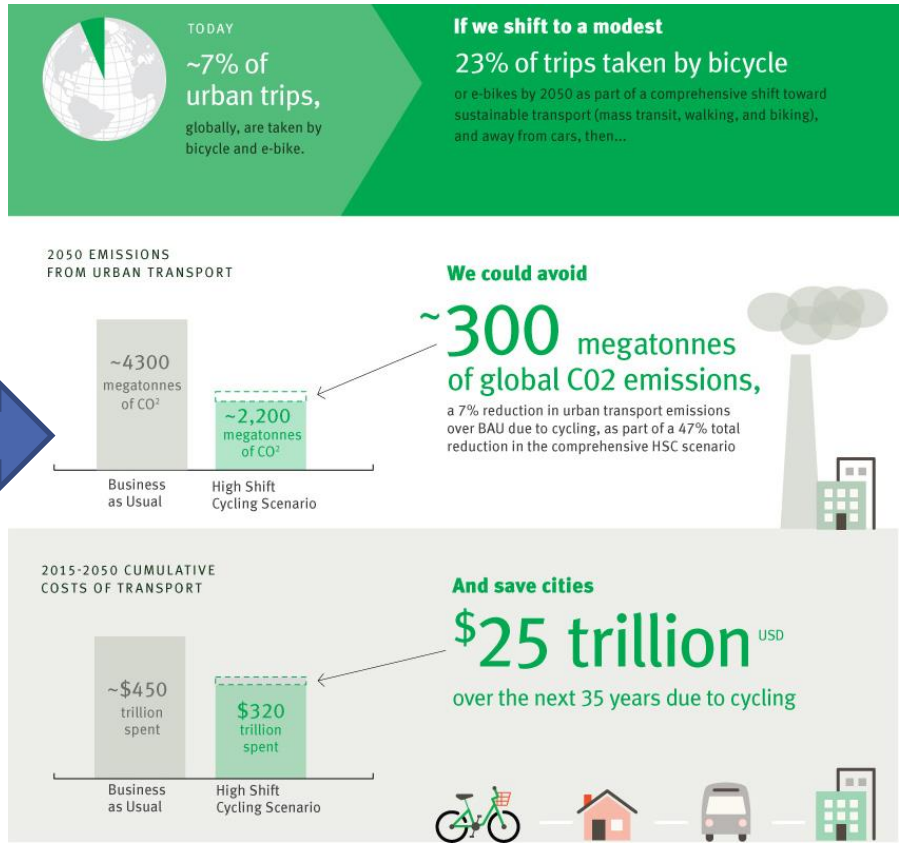
Transport transition- the modelling challenge

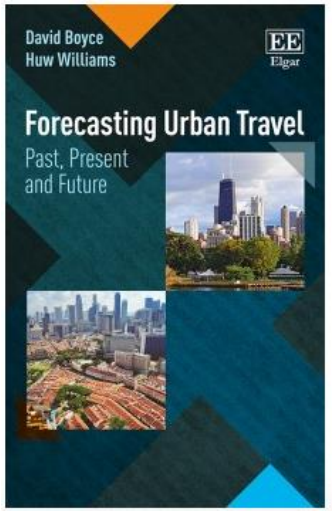




'Avoid' and 'shift' instead of 'improve'

LUTM can aid the transition!

- Systemic change is a long process
  - Involves institutional change (Beddoe et al, 2009)
  - Models are leverage points in the system
  - **Models can help speed-up change**
- **Backcasting** – we know where we need to be, but how do we get there?
- "Transport modelling shows that we can't do that because queues will be too long."
- "To make O'Connell Street how we want it we need to reduce traffic, so use your models to work out how to do it."



Beddoe, R. Costanza, R. Farley, J. Garza, E. Kent, J. Kubiszewski, I. Martinez, L. (2009), 'Overcoming System Roadblocks to Sustainability: The Evolutionary Redesign of Worldviews, Institutions, and Technologies'. Proceedings of the National Academy of Sciences, 106(08): 2483-9

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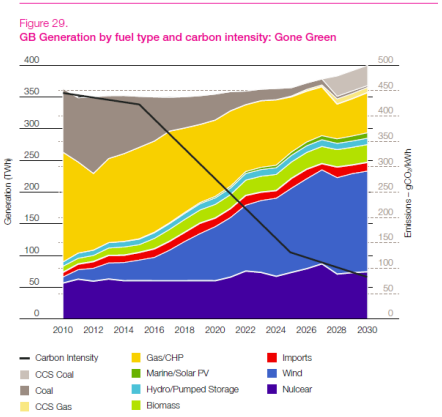
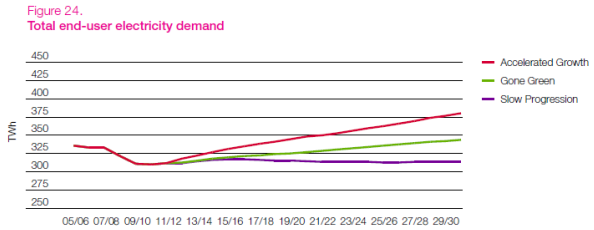
London Mitigation Options

- Three main sources:
  - Transport, domestic, non-domestic
- Supply from National Grid
  - No imminent decarbonisation
- Demand reduction vital
  - How to achieve? How to model?
  - Portfolios of measures?
  - Land-use, transport, economics…
  - Passengers and freight
  - Energy efficiency = energy waste?





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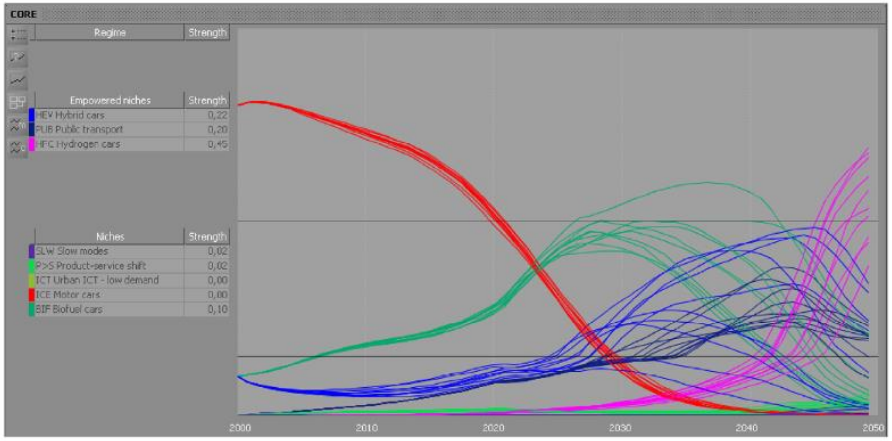
Modelling transitions

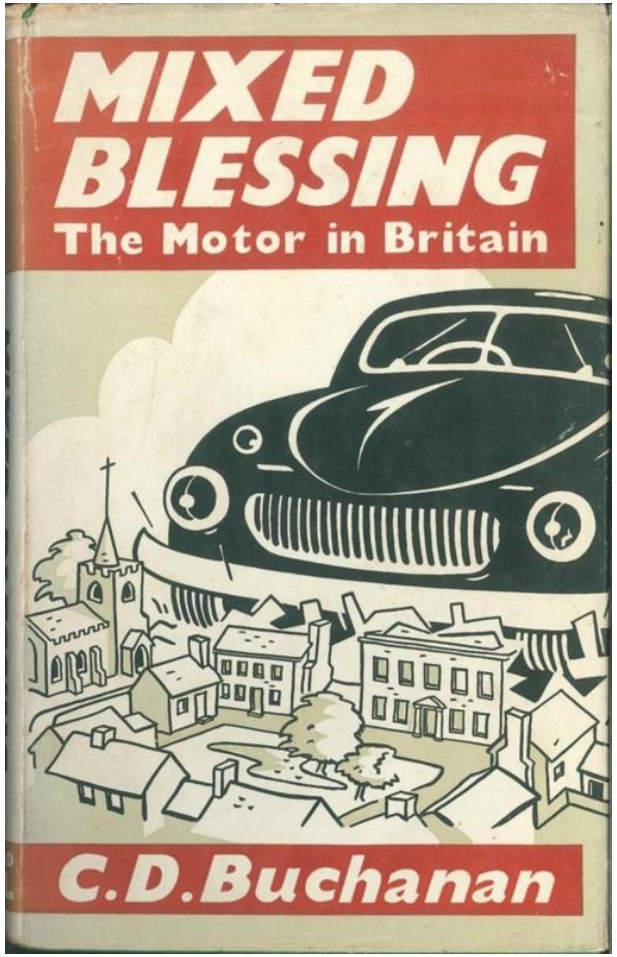
- Hickman and Bannister (2009)
  - Developing future scenarios
  - Packages of options
- Ruhr Model (Wegener et al)
- ReVisions multi-scale
  - Sustainable urban development
- Kohler et al (2009)
  - Transition theory for mobility
  - Uptake of new regimes
  - Role of space and urban form?
- How radical can we be?!



Radical ‘futures’

“Three main civilian uses have been found for the motor vehicle: the ordinary motor car for the transport at will of the owner and his family, the bus and coach for the mass transit of people, and the goods vehicle. Private motor cars constitute by far the largest group of motor vehicles, but it may be questioned whether they play a key or dominating part in economic affairs… A test that may be applied is to consider what the effect would be if by some means all cars were suddenly to be withdrawn from use. Supposing this to happen, it seems doubtful whether any severe breakdown or dislocation of business or industry would follow, though there would certainly be much inconvenience.”

1958



Thanks to John Dales, UrbanMovement.co.uk

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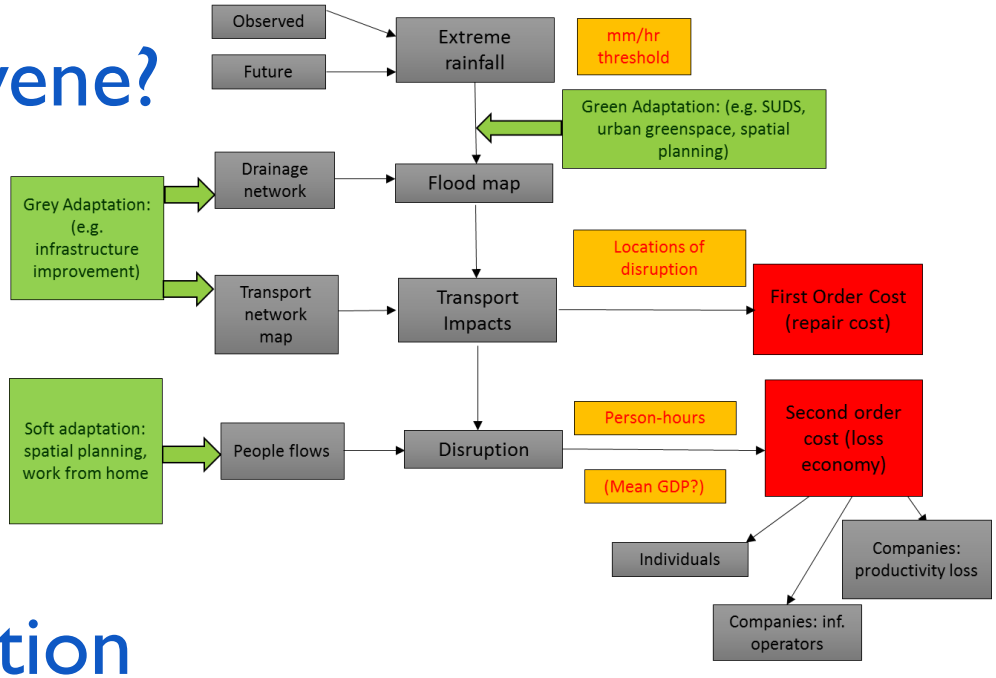
What about adaptation?

- Even 1.5°C warming is a significant change
- How to improve resilience?
- Where best to intervene?
  - Grey adaptation
  - Green adaptation
  - Soft adaptation
- Cost vs effectiveness
- Not sacrificing mitigation
  - Trade-offs and complexities



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Risk from Multiple Hazards

Hazard:

'A potentially damaging physical event' (UN/ISDR 2004)

Climate Change

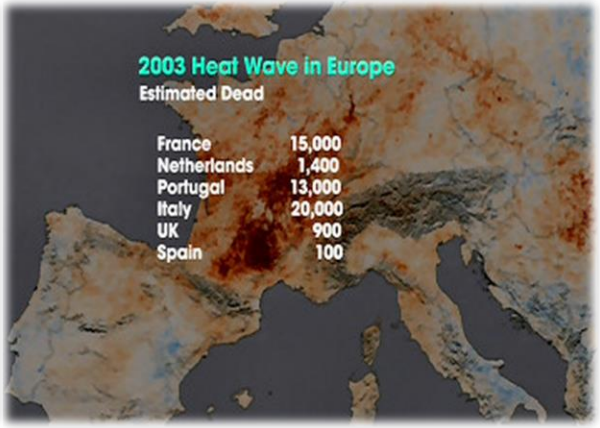
Vulnerability:

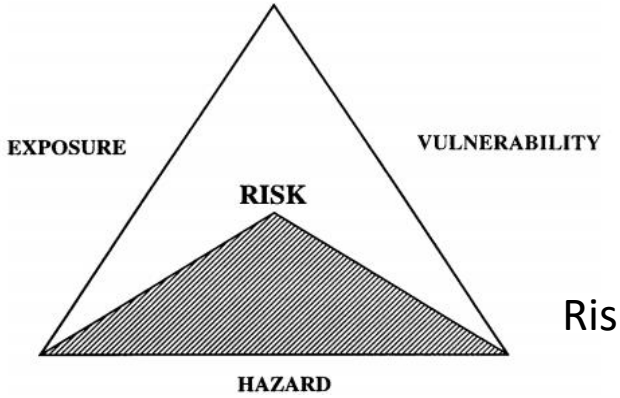
'The characteristics of group in terms of their capacity to resist' (IFRC 1999)

Socio-economic Change (LUTM)

Exposure:

'The nature and degree to which a system is exposed to significant climatic variations' (IPCC 2001)





Crichton's triangle (1990)

Risk = Hazard * Exposure * Vulnerability

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Spatial Heat Risk Framework

Heat Hazard:

Current day surface temperatures.

UK Met Office weather stations.

UKCP09 Climate Projection

Statistical spatial weather g

Population Vulnerabili

2001 & 2011 census data.

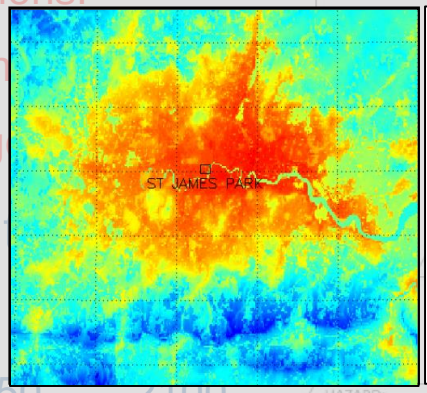
Population model 2020, 2050, …, 2100.

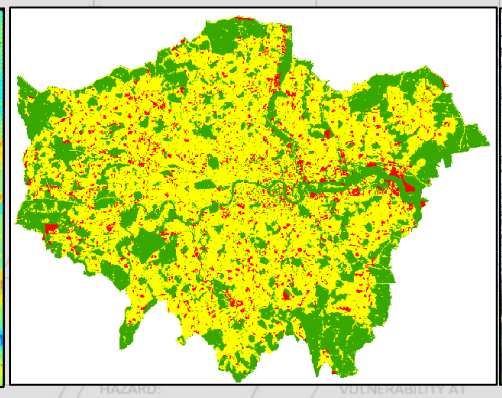
Building Exposure:

Ward level building statistics.

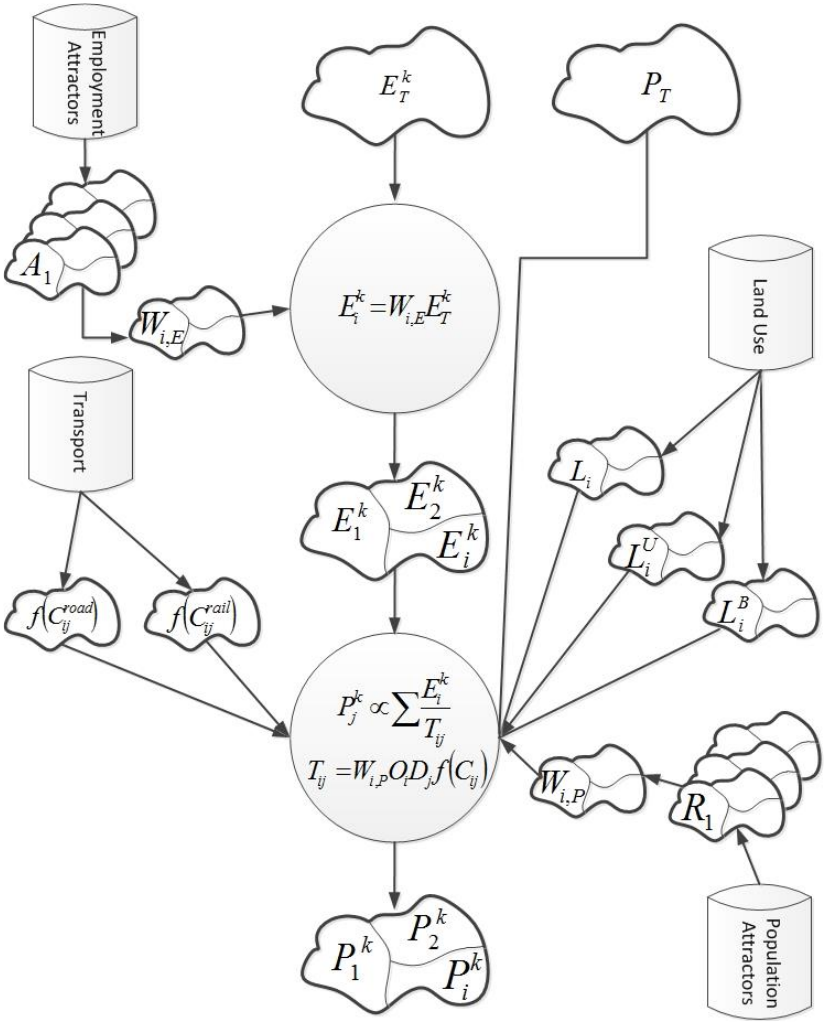
Individual building classification.

Urban Development Model.





Future Population Scenarios



Simple Lowry-style model

Headline scenarios

- Simple assumptions
- Quick to run
- Easy to explain

Ward-level employment figures

- 10 industrial sectors

Attractor-driven

- Accessibility, Floorspace, Land available

Three future planning scenarios

- BA, Decarbonisation, Deregulation

Future scenario drivers

- Transport infrastructure
- Employment locations
- Planning controls

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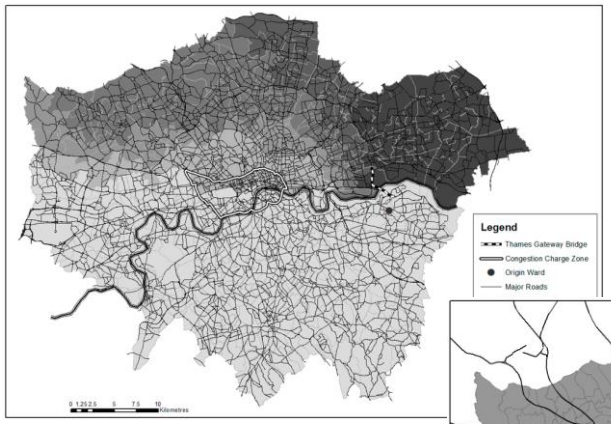
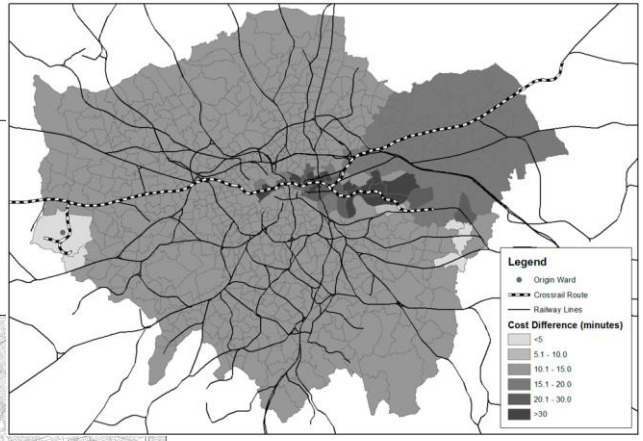
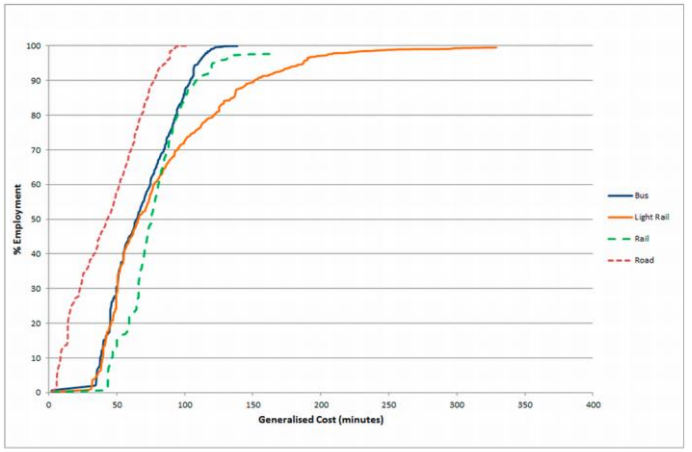
Accessibility and travel costs







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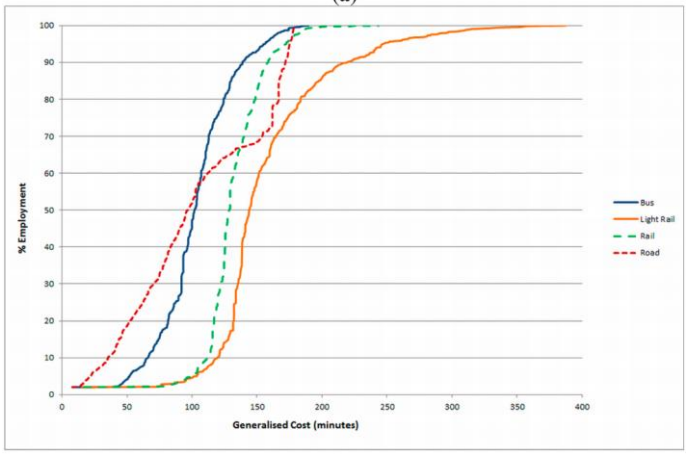

(b)

(Ford et al, 2015)

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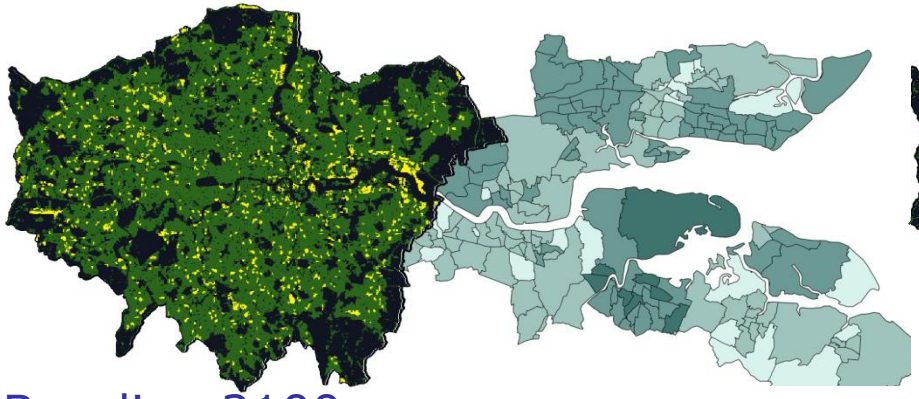
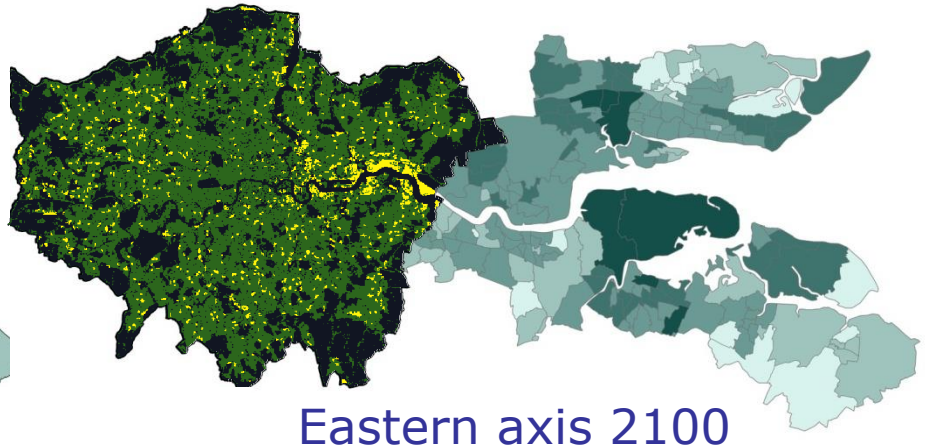
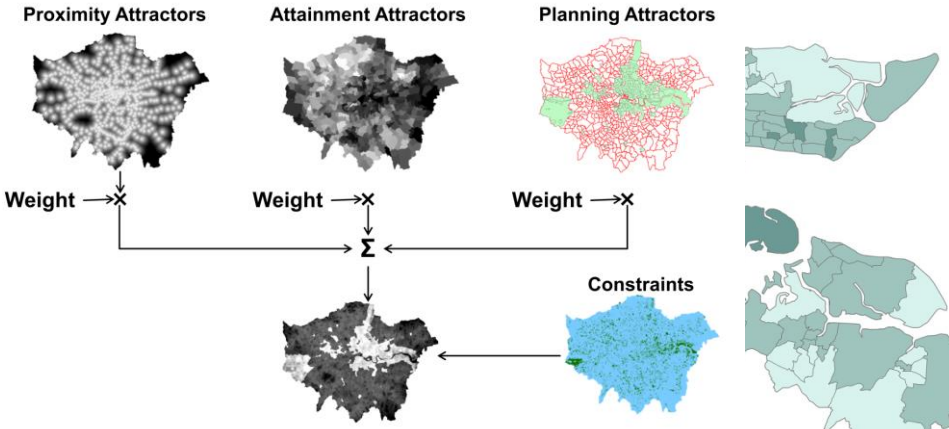
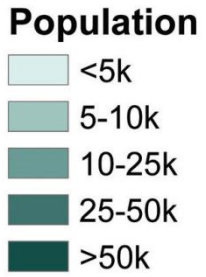


Baseline 2100

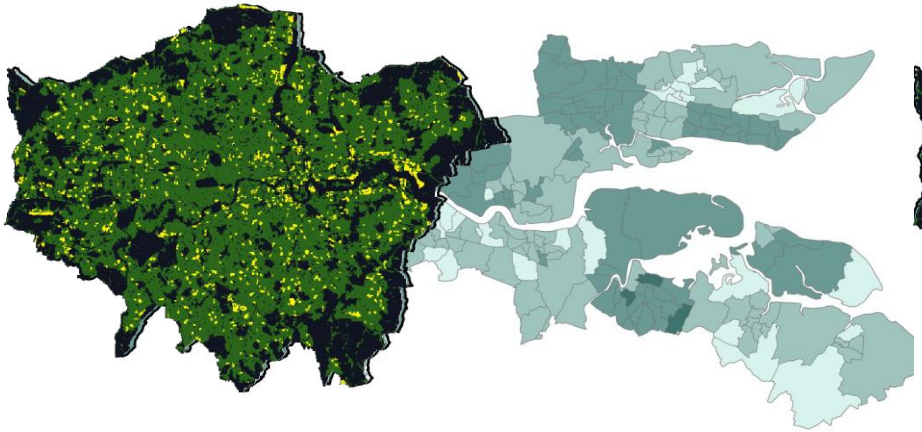


Eastern axis 2100

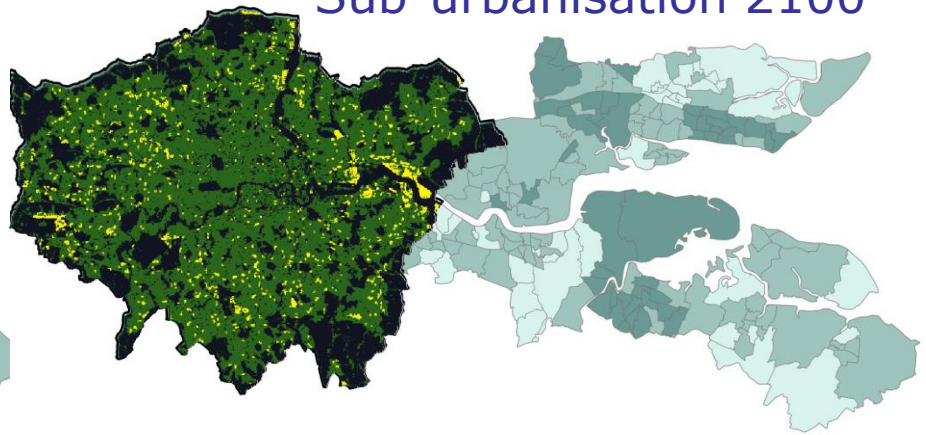




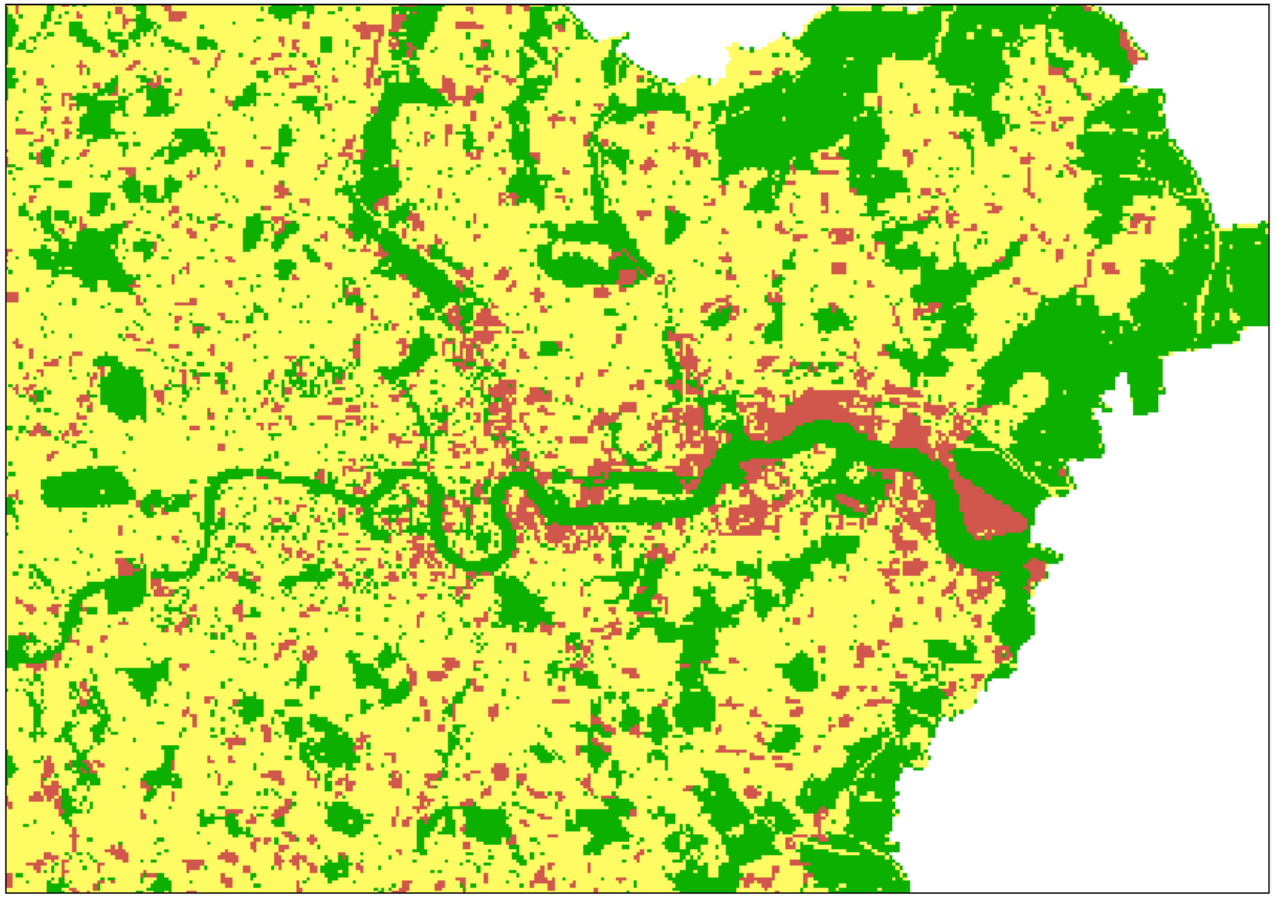
Centralisation



Sub-urbanisation 2100



Planning Policy – Thames Flooding



Legend

- Undeveloped Land
- Previous Development
- New Development

0 2.5 5 10 15 20 Kilometres

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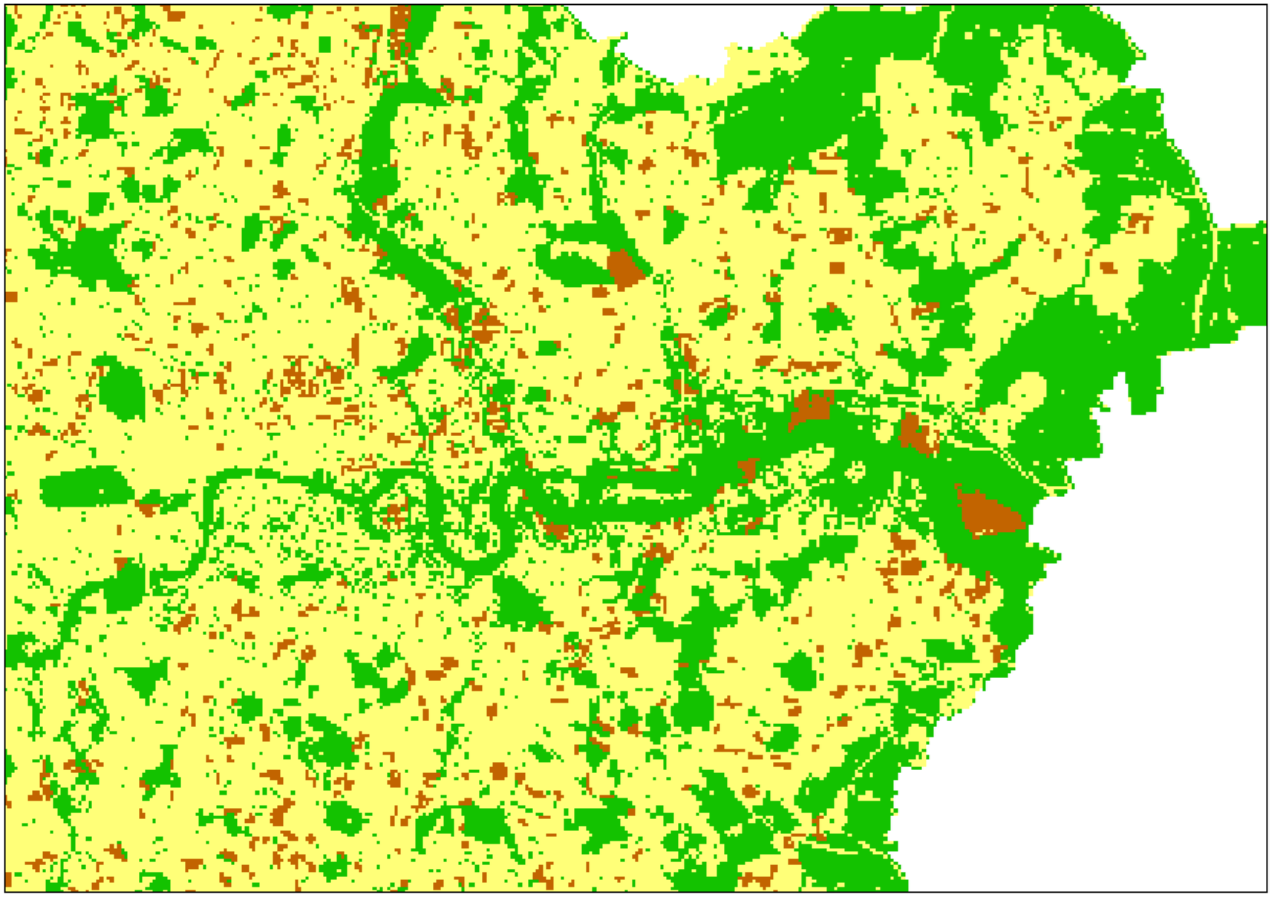
Planning Policy – No floodplain development



Legend

- Undeveloped Land
- Existing Development
- New Development

0 2.5 5 10 15 20 Kilometres

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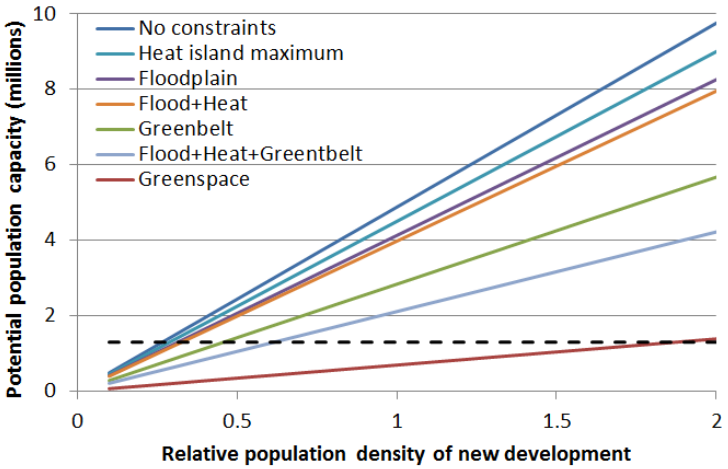
Competing land-use pressures

Eastern BAU

Eastern No Floodplain

Eastern Greenbelt Lifted



Some pictures of high-density vs sprawl vs ecotowns

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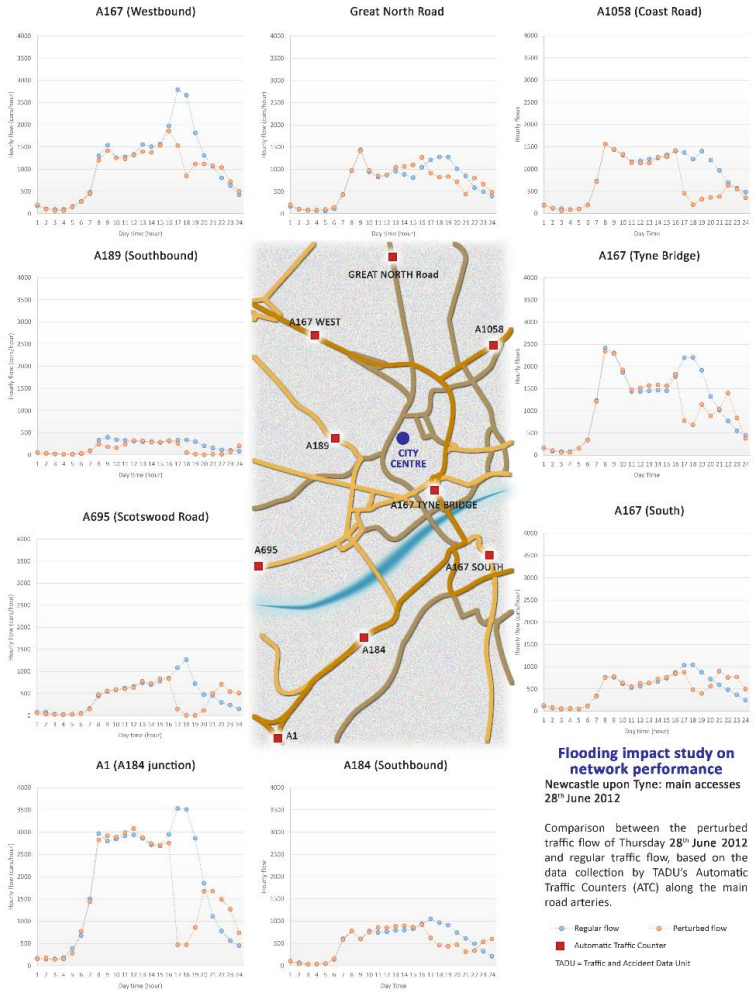
Indirect Impacts

- Impacts on urban function
  - Flooded transport links
  - Closed stations
  - Rail buckles from heat
  - Catenary blown down
- Complex interactions
  - Interdependency
  - Spatial distribution
  - Knock-on effects



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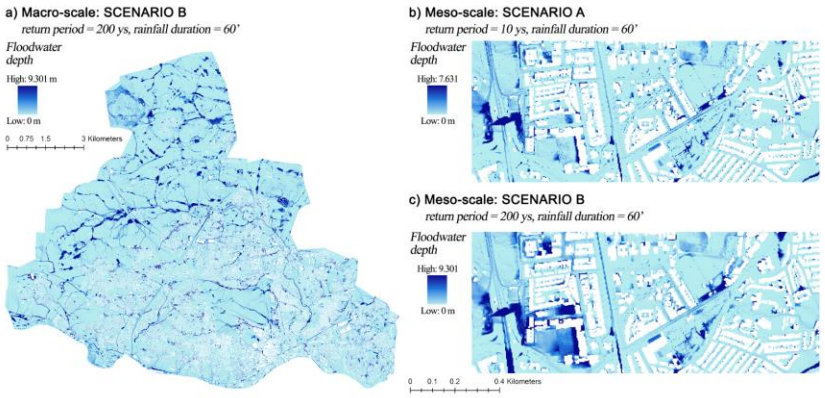
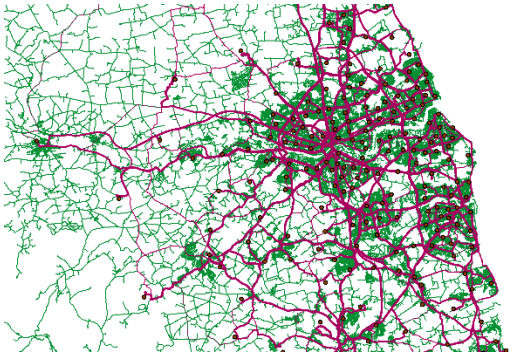
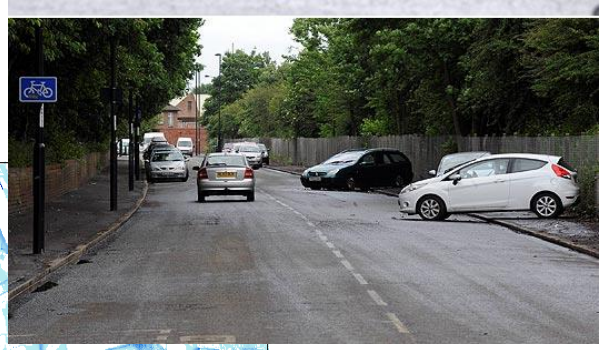
Transport and Floods

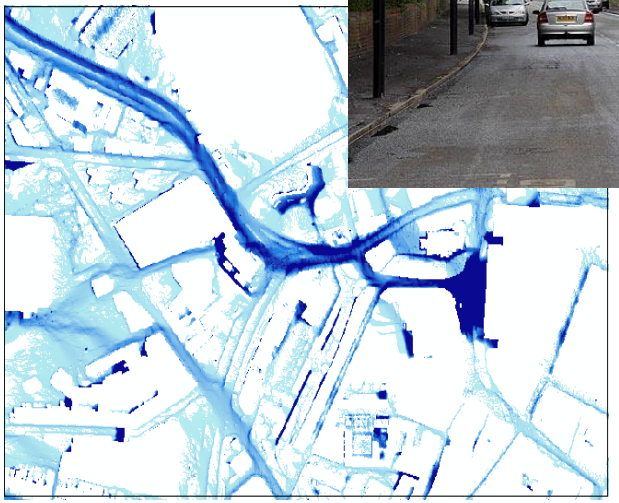


Hazard



Exposure





Vulnerability

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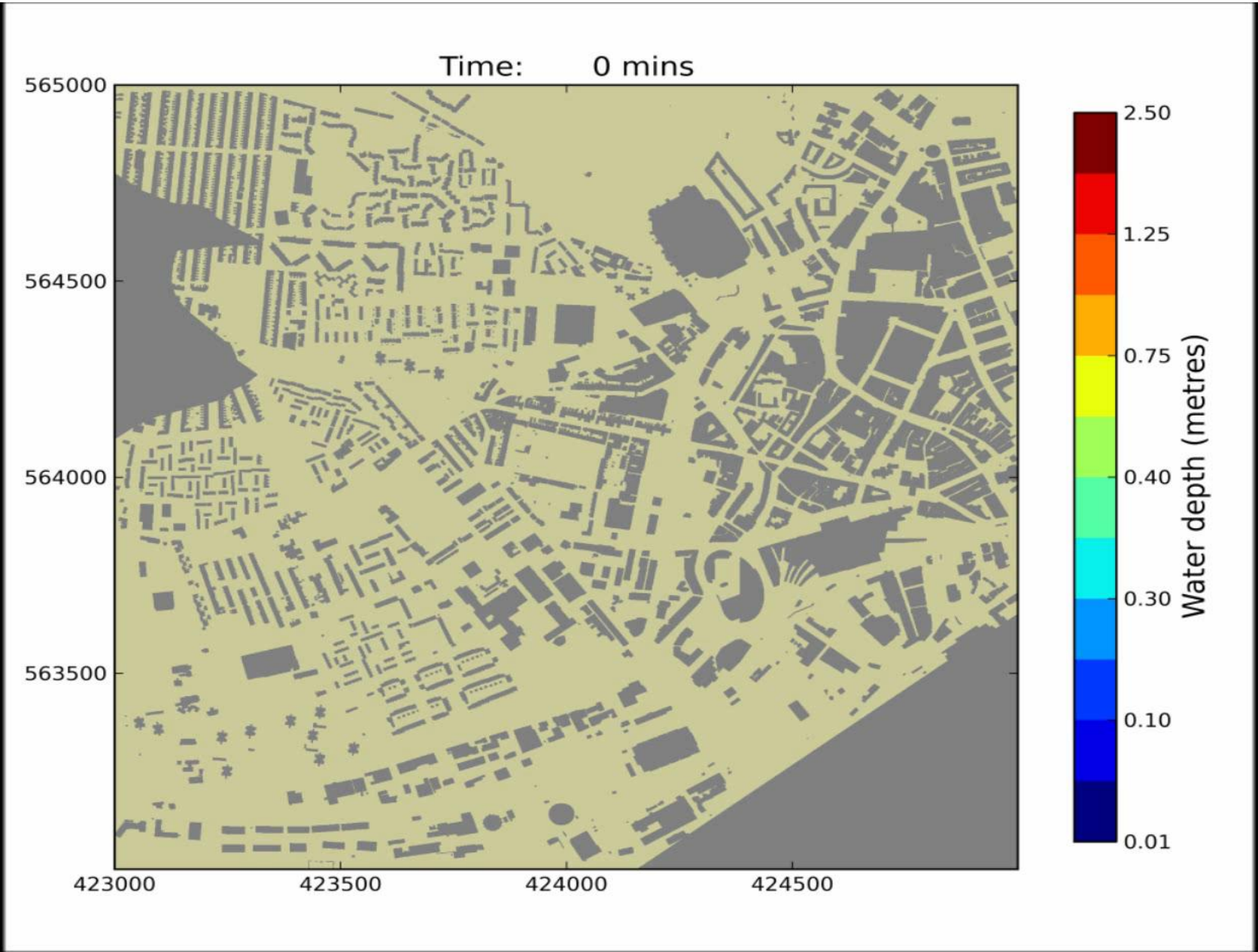
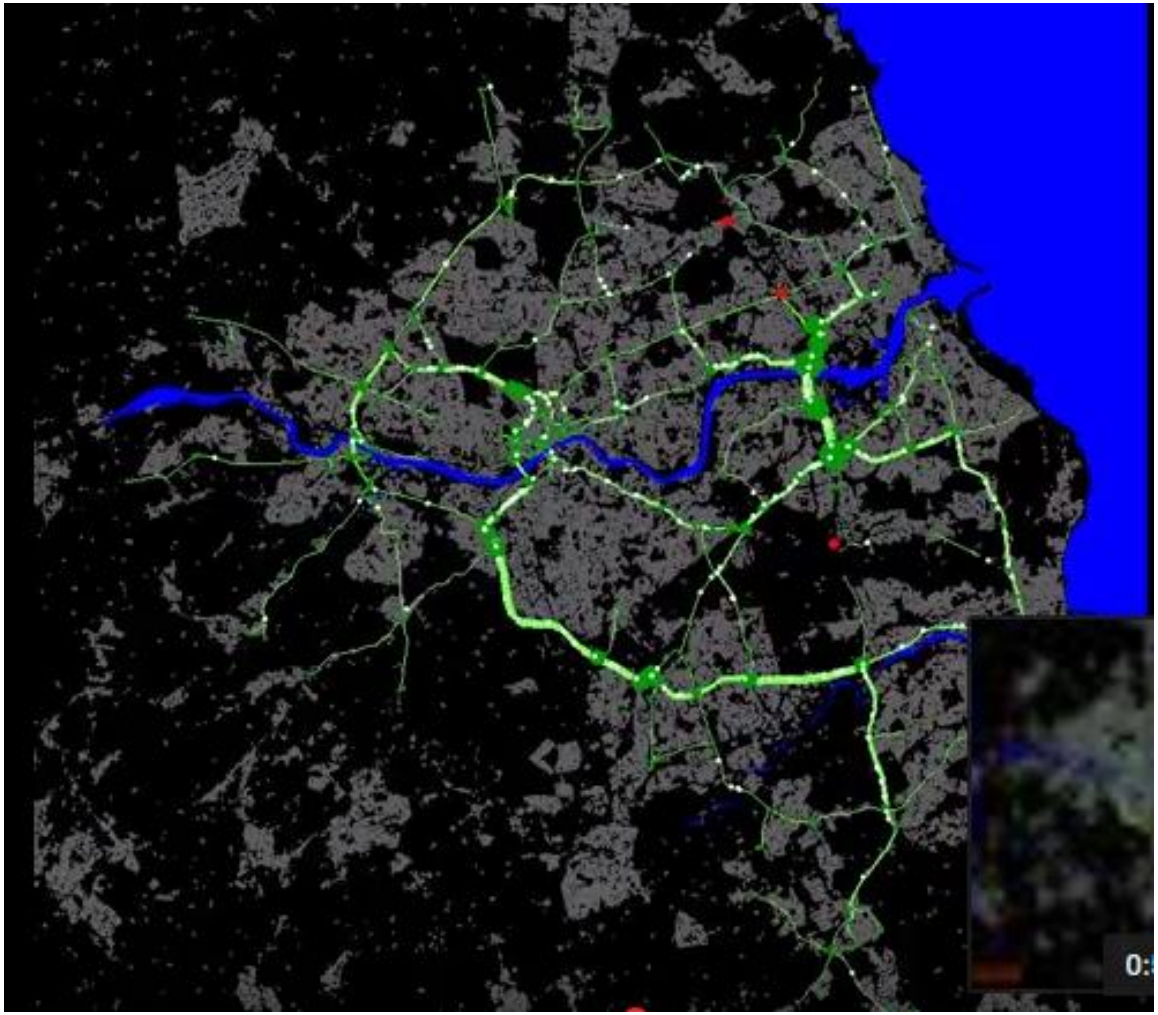
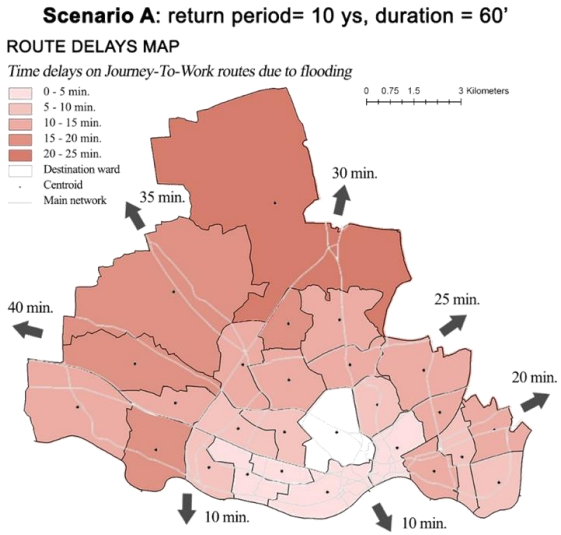
Pluvial flooding

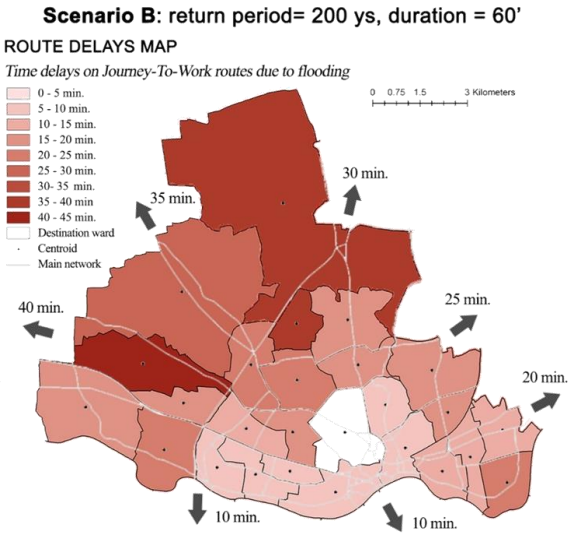


Linked Dynamic Simulations?



Costs and Benefits





HIGHER PROBABILITY EVENTS

scenario		current		2080s	
label	**no. link hardened**	**total time of delay [hrs]**	**person hour delay**	**total time of delay [hrs]**	**person hour delay**
NA	0	2088.91	16847	2791	22238
LH_1	1	1947.50 (-6.85%)	16037 (-4.8%)	2707.33 (-3.0%)	21679 (-2.6%)
LH_2	2	1886.81 (-9.7%)	15725 (-6.6%)	2565.31 (-8.1%)	20824 (-6.4%)
LH_3	3	1818.30 (- 13.0%)	15456 (-8.3%)	2503.61 (-10.3%)	20570 (-7.5%)

LOWER PROBABILITY EVENTS

scenario		current		2080s	
label	**no. link hardened**	**total time of delay [hrs]**	**person hour delay**	**total time of delay [hrs]**	**person hour delay**
NA	0	2791	22238	4224	33594
LH_1	1	2707.33 (-3.0%)	21679 (-2.6%)	4081.18 (- 3.4%)	33594 (-2.3%)
LH_2	2	2565.31 (-8.1%)	20824 (-6.4%)	3933.38 (-6.9%)	32720 (-4.8%)
LH_3	3	2503.61 (-10.3%)	20570 (-7.5%)	3808.13 (-9.4%)	32270 (-6.1%)

Cost of adaptation? Picture of green vs grey?
Co-benefits?

Pregnolato M, Ford A, Glenis V, Wilkinson S, Dawson R. Potential impact of climate change on flooding disruptions to urban transport networks, ASCE Journal of Infrastructure Systems, Accepted for Publication.

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Targeting adaptation

- What type is most effective?
  - Grey vs Green vs Soft
- Where are the critical locations?
  - On links? Upstream? Dispersed?
- What are the costs and benefits?
  - Is VoT a valid measure?
- Incremental and flexible?
  - Deal with uncertainty?

Pregnolato M, Ford A, Robson C, Glenis V, Barr S, Dawson RJ. Assessing urban strategies for reducing the impacts of extreme weather on infrastructure networks. *Royal Society Open Science* 2016, **3**(5), 160023.

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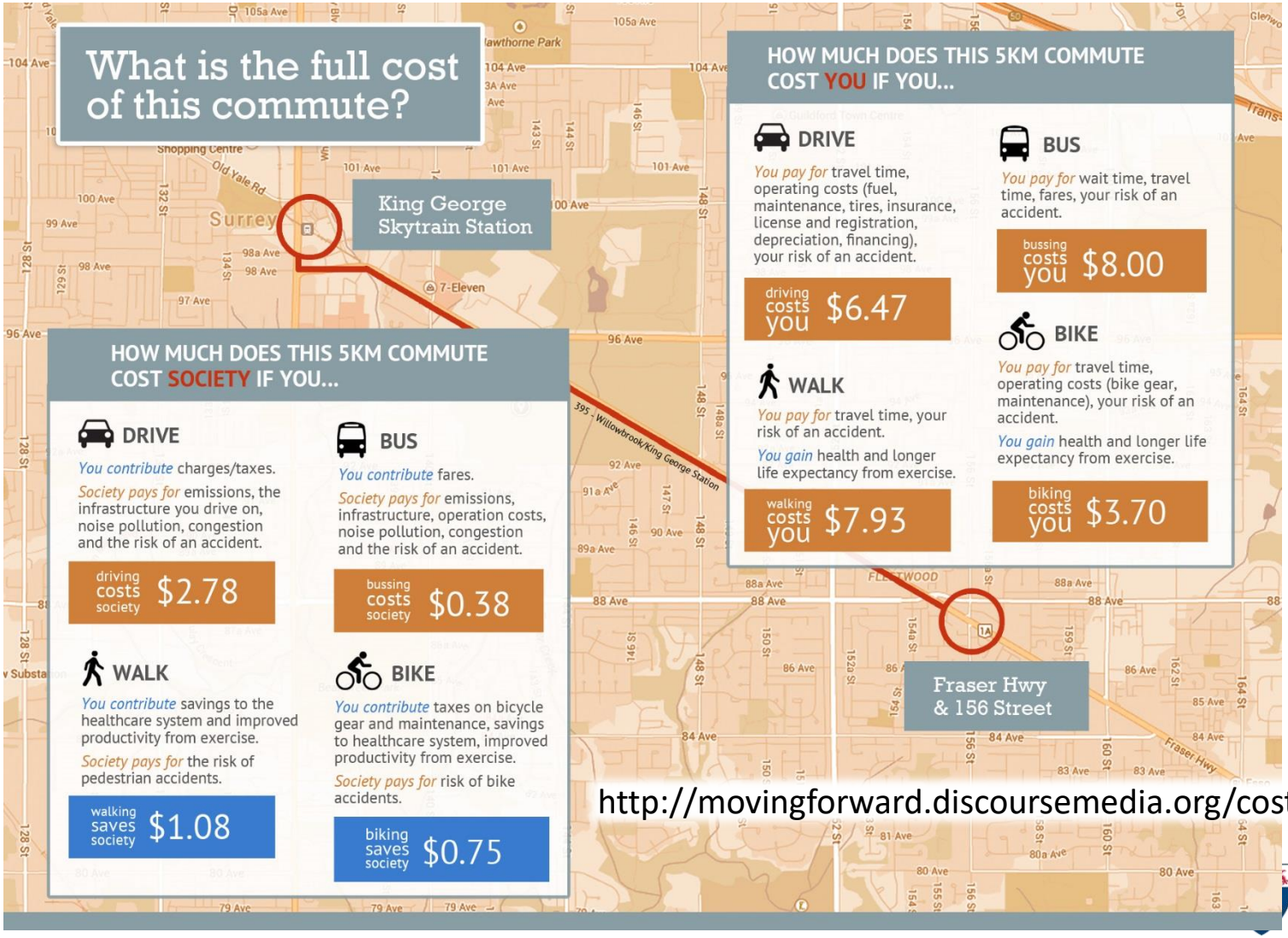
Making it all easier – co-benefits and externalities?



http://movingforward.discoursemedia.org/costofcommute/

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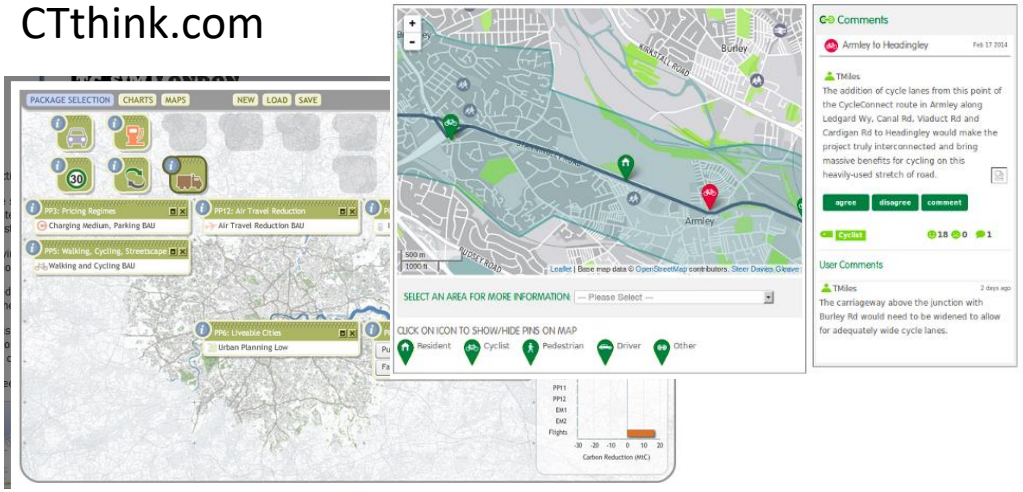
Models as discussion tools

- Models are often expensive, and misuse is dangerous!
  - Often black box, blunt, complex, and inaccessible
- What place for simple 'conversational modelling?'
- Co-creation?
- Participatory planning
- Getting community buy-in
  - Big changes require brave politicians
  - Easier if public opinion is on your side
  - The need to do the 'right' thing, not the popular thing!

Who will save us from the misuse of transport models?

CTthink.com



Keep	Replace	How
Terminology	Inaccessible	Online tools
Equations	Proprietary ownership	Open source licences
Use of scenarios	Ageing software	New software
	Narrow scenarios of future	Flexible models
	Black boxes	Simple and open method

Robinlovelace.net

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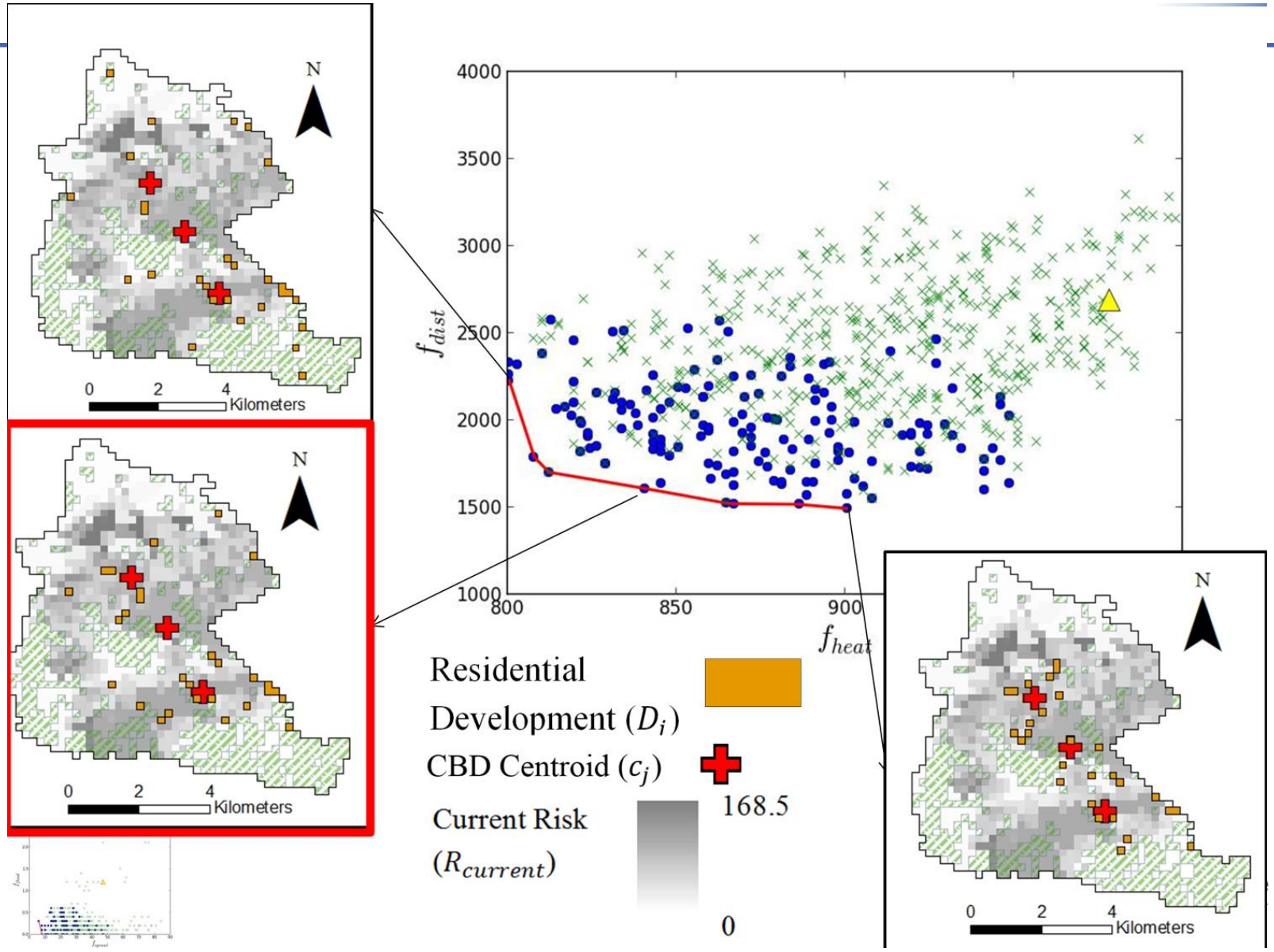
Uncertainty – ensembles of models?



THE END (OR IS IT THE BEGINNING?)

Alistair Ford + many, many colleagues
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www.ramses-cities.eu

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EPSRC Engineering and Physical Sciences Research Council

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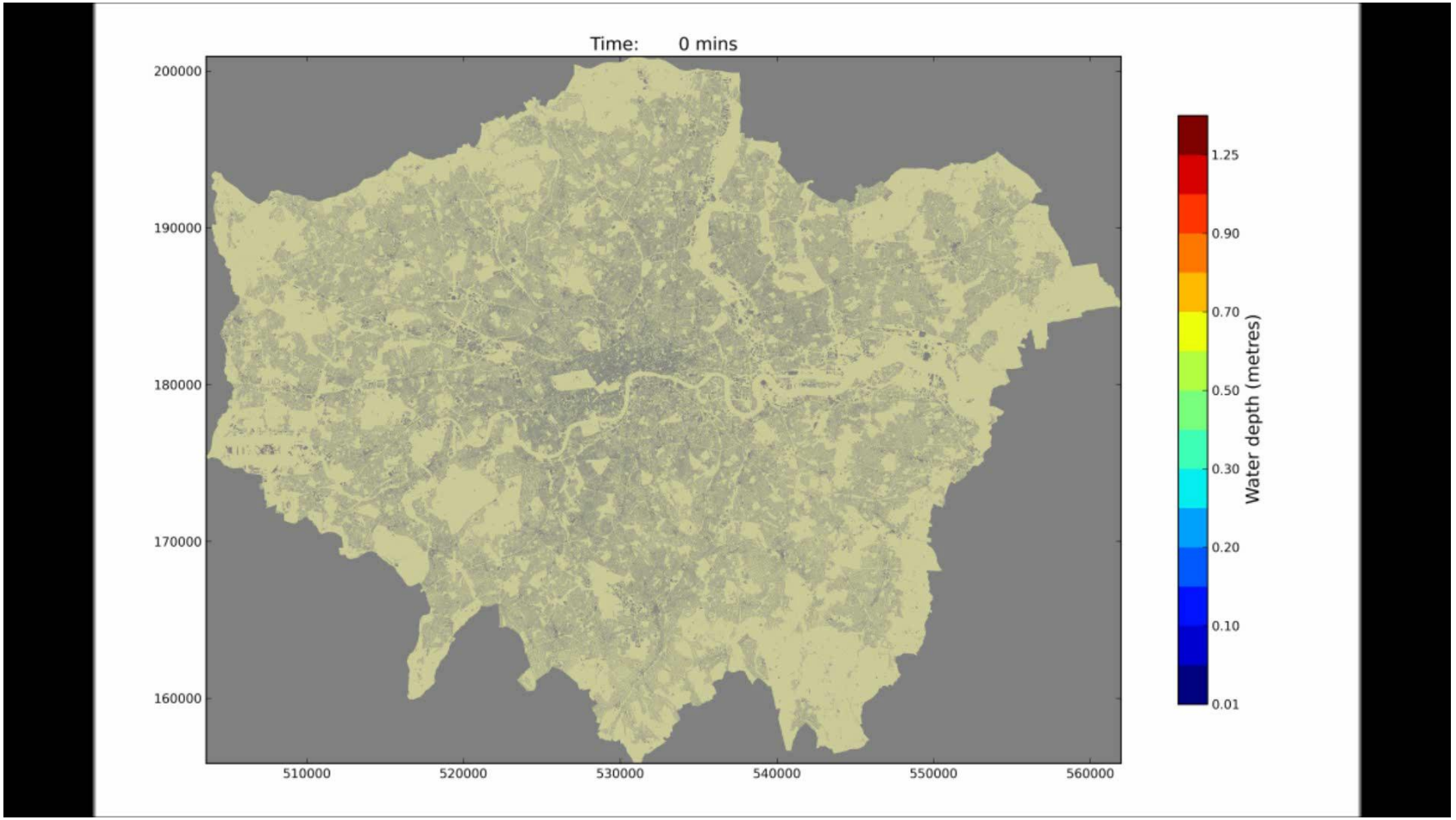
Tyndall Centre for Climate Change Research

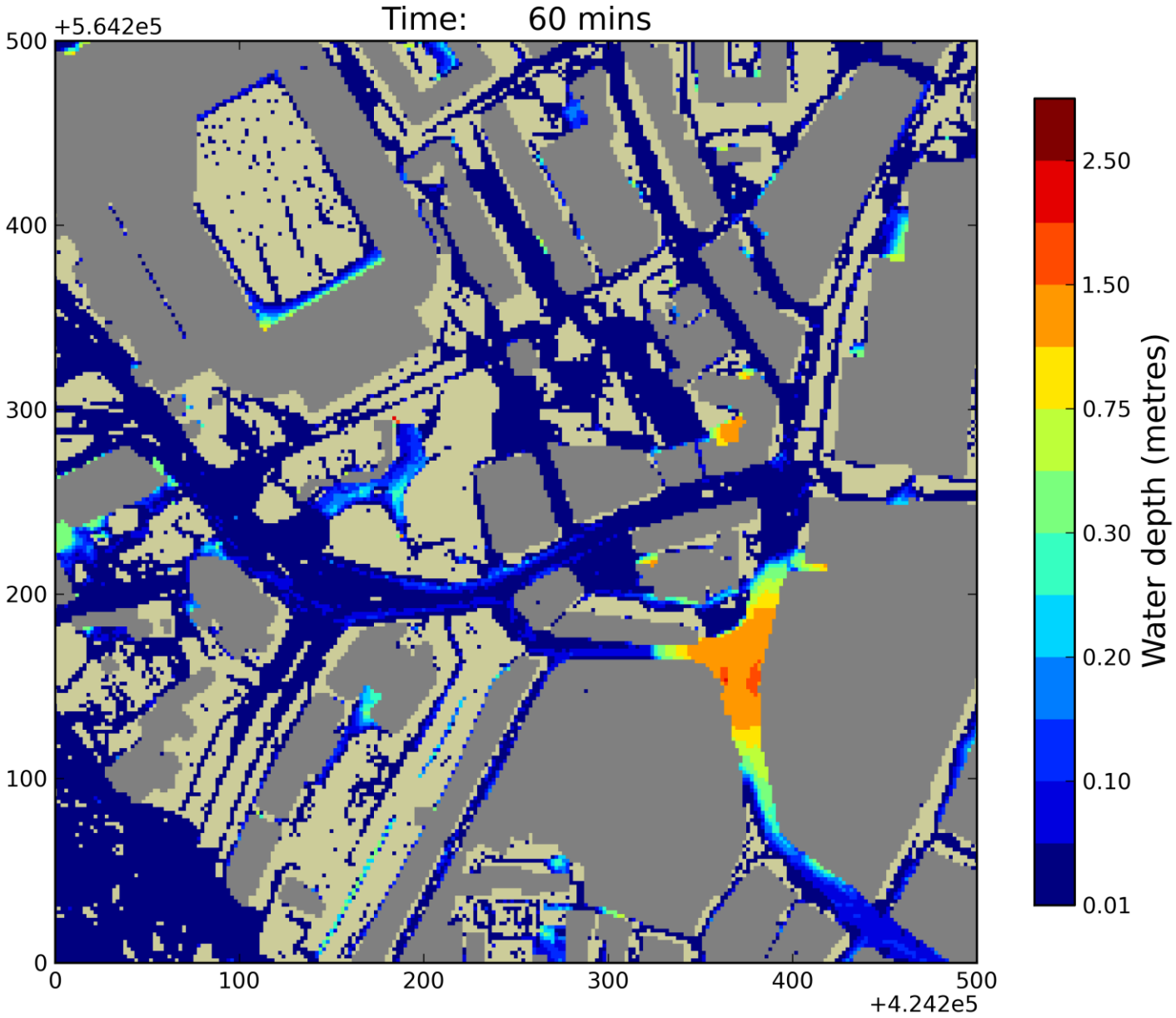
Newcastle University

RAMSES
Science for cities in transition

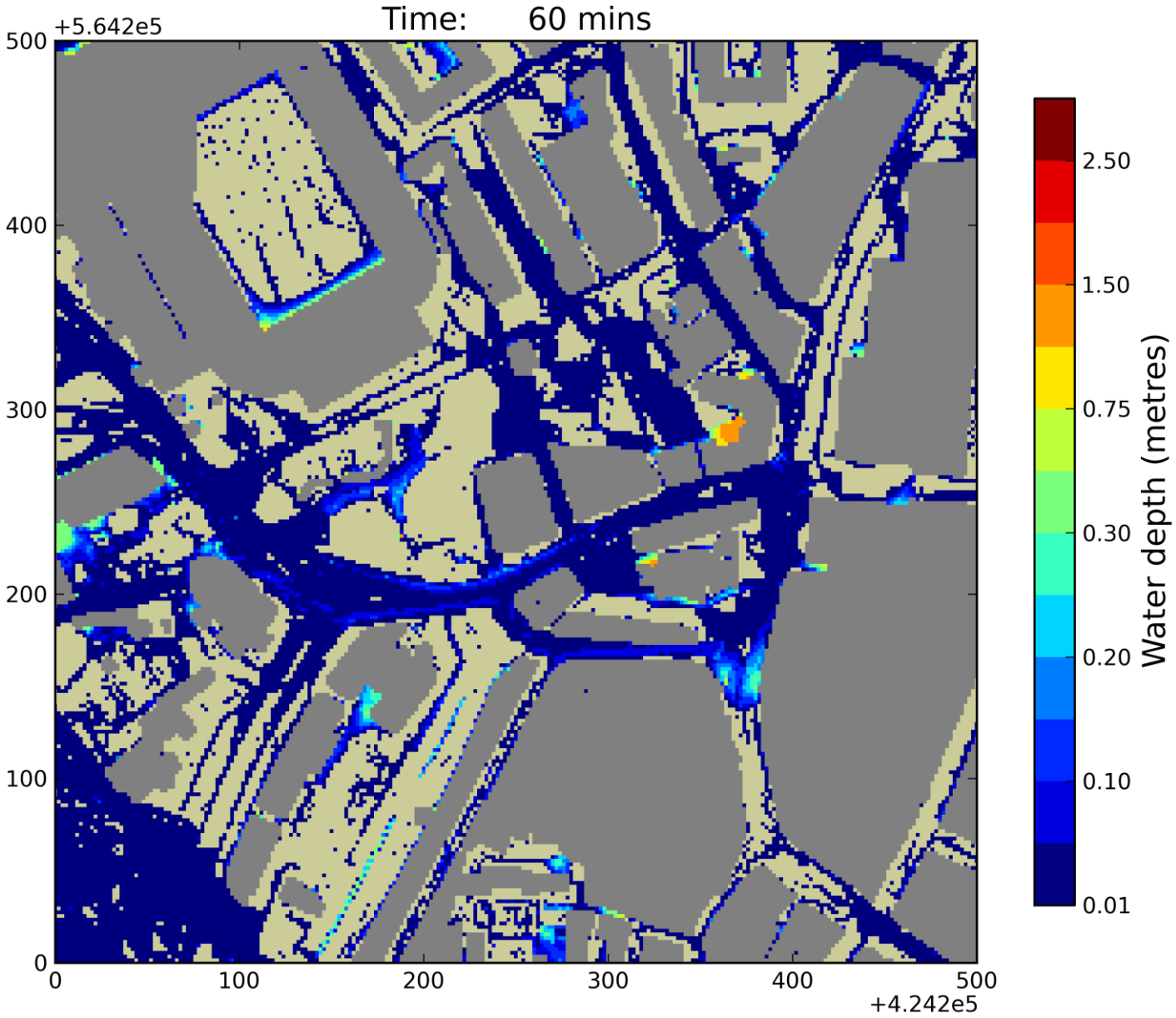
London Simulations



Surface flow only, RP = 50yrs



Surface flow + Drainage network, RP = 50yrs

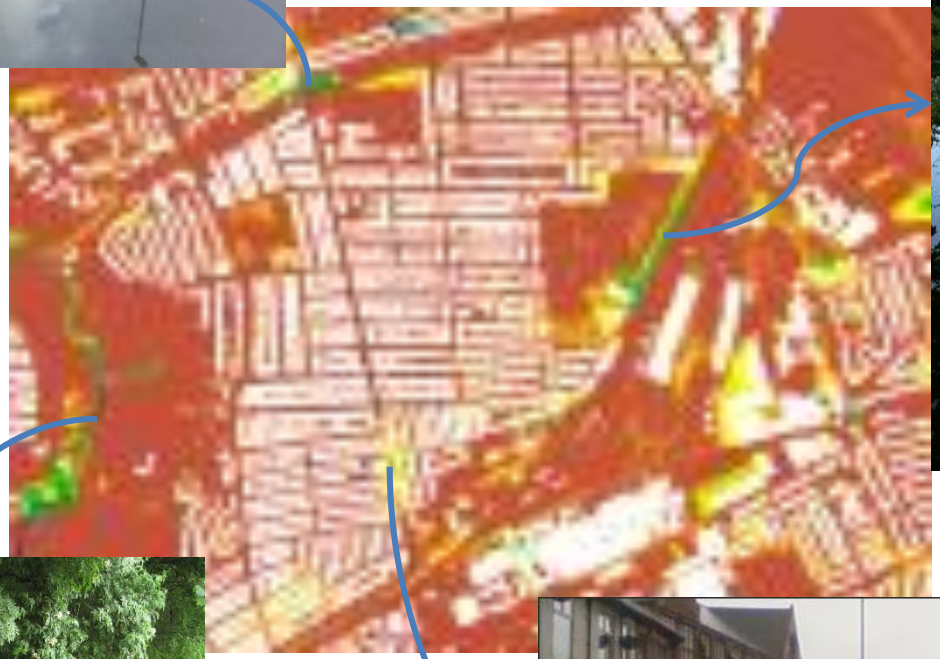


CityCAT simulation within the Cloud Computing project

100Y return period/ 1 hour duration (37.3mm)

time= 1 hour into simulation

Model depth=1.45cm



Model depth= 0.45cm