Climate Change Adaptation in Cities: Extreme Weather and Integrated Responses

Alistair Ford + Hayley Fowler,
School of Civil Engineering and Geosciences, Newcastle University

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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 Parties have ratified the 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.
Implications

“War-like footing” – Kevin Anderson, Tyndall Centre

“33% change of achieving 2°C” – IPCC

- 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
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.
## Adaptation vs Mitigation

<table>
<thead>
<tr>
<th>Response</th>
<th>Potential benefit</th>
<th>Potential negative impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Densification</td>
<td>Reduce public transport emissions and better accessibility</td>
<td>Increased urban heat islands, noise pollution and surface water run off</td>
</tr>
<tr>
<td>Air conditioning</td>
<td>Reduced heat stress</td>
<td>Increases energy use and consequently emissions</td>
</tr>
<tr>
<td>Raising flood defences</td>
<td>Reduce flood frequency</td>
<td>Encourages development in riskier areas</td>
</tr>
<tr>
<td>Dispersed development</td>
<td>Improved wellbeing, reduced flood damages</td>
<td>Increased private vehicle emissions</td>
</tr>
<tr>
<td>Desalination plants</td>
<td>Secure water supply</td>
<td>Increase greenhouse gas emissions</td>
</tr>
<tr>
<td>Irrigation</td>
<td>Supplying water for food</td>
<td>Salinisation of soil, degradation of wetlands,</td>
</tr>
<tr>
<td>Biofuels for transport and energy</td>
<td>Reduce GHG emissions</td>
<td>Encourage deforestation; replace food crops raising food prices; can increase local air quality pollutants such as NO&lt;sub&gt;x&lt;/sub&gt;</td>
</tr>
<tr>
<td>Catalytic convertors</td>
<td>Improve air quality</td>
<td>Large scale mining and international resource movements</td>
</tr>
<tr>
<td>Cavity wall insulation</td>
<td>Reduce GHG emissions</td>
<td>Increase damages from a flood event</td>
</tr>
<tr>
<td>Pesticides</td>
<td>Control vector borne disease</td>
<td>Impact on human health, increased insect resistance</td>
</tr>
<tr>
<td>Conservation areas</td>
<td>Preserve biodiversity and ecosystems</td>
<td>Loss of community livelihoods</td>
</tr>
</tbody>
</table>

*etc ......*

Adapted from Dawson (2011) Potential pitfalls on the pathway to sustainable cities ... and how to avoid them, *Carbon Management*, Vol 2(2)
The need to understand changes to extreme weather: heavy rainfall
The need to understand changes in extreme rainfall

Brisbane, 2011

Newcastle, 2012
Diurnal Cycle in Summer US Rainfall

CPM improves diurnal cycle of the amount, intensity, and frequency of precipitation


Courtesy: Andreas Prein, NCAR
Relationship between Temperature and Precipitation

C-C scaling
Super C-C scaling
Reversal
Convection Permitting Models (CPMs)

- CPM grid spacing ≤ 4 km
  - Weather forecasting
    - Weisman et al. 1997
    - Done et al. 2004
  - Climate
    - Langhans et al. 2012

Courtesy: Andreas Prein, NCAR
First regional CPM simulations at 1.5km resolution over UK

- First climate simulations at convection-permitting scales
- Span southern England and Wales at 1.5km resolution.
- Driven by 12km European RCM, which is in turn driven by ERA-interim or 60km HadGEM3.
- Explicitly represents convection without need for parameterisation scheme.
### Summary of projections from very high resolution models

<table>
<thead>
<tr>
<th>Changes which are likely to be robust from coarser to higher resolution models, driven by large-scale changes inherited from global climate model</th>
<th>Changes for which representation of the local storm dynamics, or high resolution orography, is important</th>
</tr>
</thead>
<tbody>
<tr>
<td>=&gt; Confidence in coarse resolution climate model projections</td>
<td>=&gt; Need for very high resolution (km-scale) model for accurate projections</td>
</tr>
<tr>
<td>Decrease in summertime mean rainfall</td>
<td>Intensification of hourly rainfall in summer</td>
</tr>
<tr>
<td>Increase in wintertime mean rainfall</td>
<td>Changes in hourly and daily summertime extremes</td>
</tr>
<tr>
<td>Increase in heavy rainfall in winter</td>
<td>Increases in multi-hourly rainfall extremes over steep orography in winter</td>
</tr>
<tr>
<td>Large decrease in rainfall occurrence in summer</td>
<td>Changes in rainfall duration</td>
</tr>
</tbody>
</table>

Kendon et al, BAMS, in press
Adapting to extreme events?

- Observed
- Future
- Extreme rainfall
- mm/hr threshold
- Green Adaptation: (e.g. SUDS, urban greenspace, spatial planning)

- Grey Adaptation: (e.g. infrastructure improvement)
  - Drainage network
  - Flood map

- Transport network map

- Transport Impacts

- Soft adaptation: spatial planning, work from home
  - People flows

- Disruption
  - Locations of disruption
  - First Order Cost (repair cost)
  - Person-hours
  - (Mean GDP?)
  - Individuals
  - Companies: productivity loss
  - Companies: info. operators

- Second order cost (loss economy)
Pluvial flooding

Newcastle city centre
Targeting adaptation

Competing land-use pressures

- Eastern BAU
- Eastern No Floodplain
- Eastern Greenbelt Lifted

Some pictures of high-density vs sprawl vs ecotowns

**Graph:**
- Potential population capacity (millions)
- Relative population density of new development

Legend:
- No constraints
- Heat island maximum
- Floodplain
- Flood + Heat
- Greenbelt
- Flood + Heat + Greenbelt
- Greenspace
Thinking on catchment scales

- Work with natural processes
- 25 features: Total \( \sim 500m^3 \) in a 6\( km^2 \) catchment
- 30% reduction in flood peak
“Avoided journeys and modal shift, uptake of improved vehicle and engine performance technologies, low-carbon fuels, …and changes in the built environment, together offer high mitigation potential”
Finding ‘optimum’ solutions
Thinking more widely – co-benefits and externalities?

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

- City planners need to balance conflicting objectives
- Climate change will bring changes to extreme events
- Newcastle researchers are modelling rainfall extremes
  - Expected to grow more severe over short durations
- Simulating impacts of these extremes on cities
- Assessing adaptation options over diff. scales
- Trade-offs and co-benefits with mitigation
- Finding sustainable solutions
THE END

Alistair Ford, Hayley Fowler, and many, many colleagues
Geospatial Engineering, Institute for Sustainability, Centre for Low Carbon Systems Engineering, Tyndall Centre ...

Newcastle University
a.c.ford@ncl.ac.uk

www.ncl.ac.uk/ceser
www.ramses-cities.eu
https://research.ncl.ac.uk/intense/aboutintense/

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