
# Modelling Urban Surface-Atmosphere Interactions

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## Introduction

### Urban Energy Balance

$$Q^* + Q_F = Q_H + Q_E + \Delta Q_S$$

$Q^*$ = net all-wave radiation; QF = anthropogenic heat flux;
$Q_H$ = turbulent sensible heat; $Q_E$ = turbulent latent heat flux; $\Delta Q_S$ = net heat storage

Many schemes have been developed to model the urban energy balance

**A number of urban features influence the Surface Energy Balance. These include:**

Altered surface emissivity and albedo; presence of materials with differing thermal and pervious properties; increased roughness caused by the presence of bluff bodies; reduced vegetation coverage; sources of anthropogenic heat

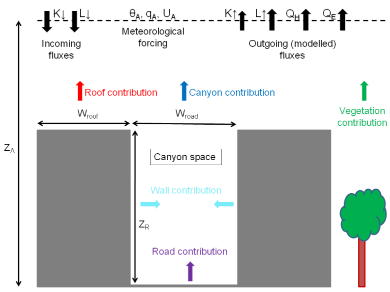
**Why is the Urban Energy Balance important?**

- It helps explain and predict the **Urban Heat Island** effect
- It can be used to inform more efficient building design and construction
- By influencing temperatures, it has a fundamental role in affecting air-quality and meteorological/climatological conditions

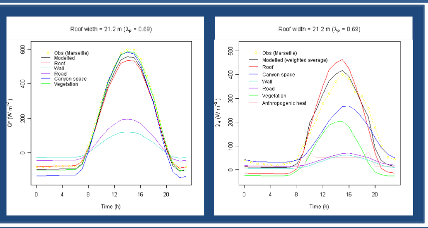
## Model examples

### NOAH / Urban Canopy Model

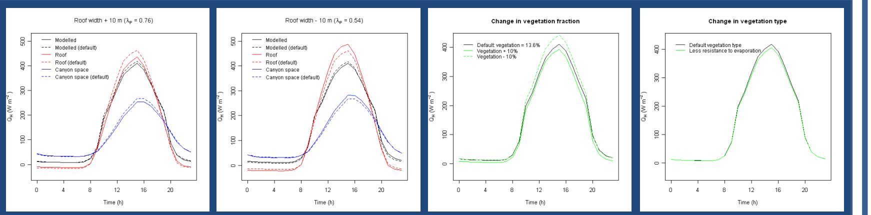
- Separate representation of vegetation and urban surfaces
- City modelled as a 2-dimensional street canyon



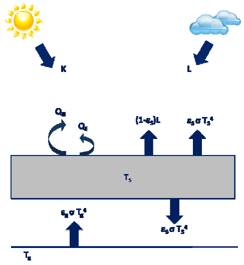

**What is the relative importance of each surface type?**



**Urban planning scenarios: what is the impact of a change in the canyon geometry or the vegetation ?**




### JULES – Joint UK Land-Environment Simulator



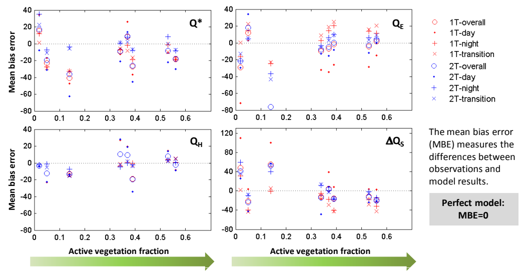
- Tile approach
- Urban surface represented as a slab
- Two model versions: 1 tile for urban surfaces (1T) or 2 separate tiles for roofs and canyons (2T)
- Low computational cost

**Application:** Operational weather forecast in the UK Met Office

**Methodology for model evaluation:**

- Comparison of modelled results against observations at different urban sites
- Initial stage using model standard parameter (default) values

**How does the model perform in urban environments containing different amounts of vegetation cover?**




## Model Intercomparison

### Urban Energy Balance Models

Comparing up to 34 different models (see examples above).

### Research Questions

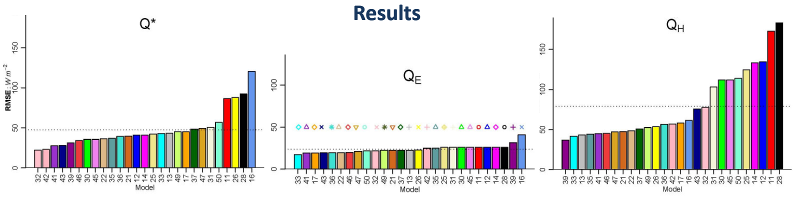
For *realistic* model performance and to assist in deriving priorities for future observational campaigns

- **Q1**. How complex must a model be?
- **Q2**. What are the main processes to be modelled?
- **Q3**. What parameter information is required?

### Methods

Modelling groups supplied with observed data → Models run → Model output compared with actual observed data

### Results




### Chief Findings

No individual model appears to show the best performance for all fluxes and periods of the day.

**Q1** **Simple** models often perform as well as, or better, than complex models

- The influence of **vegetation** is always important.
- Modelling the urban environment as just a **slab** is often sufficient.

**Q2** **Vegetation** has a key role in influencing energy and moisture exchange within the urban environment.

**Bulk characteristics** of the urban materials have a greater influence than the individual material characteristics of various aspects of the urban environment.

At night, considering **anthropogenic heat fluxes** is important

Modelling of the energy balance has best performance for **day-time periods.**

**Q3** The most important parameter is the **fraction** built and vegetated.

For simpler models, knowledge of the **urban morphology** and **urban material characteristics** is important.

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