# The Effects of Facades on Outdoor Microclimate

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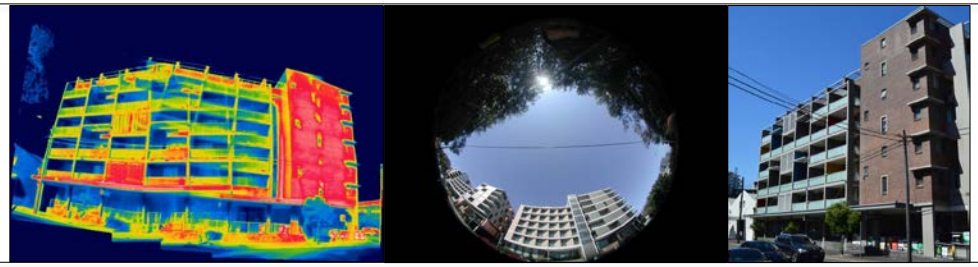

Supervisors: Prof. Alan Peters and Dr. Paul Osmond

Project RP2005 – “Urban Micro Climates: Comparative study of major contributors to the Urban Heat Island effect in three Australian cities”

**8 June 2016**

# Research Objectives

1. To develop an "**Architectural Climatology**" – methods to investigate, analyse and quantify urban surface-atmosphere exchanges at the **architectural scale**.

2. To develop a method to **predict** and **quantify** the impacts of architectural design decisions - material and spatial choices - on **outdoor surface, air** and **mean radiant temperatures**.

3. To develop **replicable**, robust methods for ground-based **urban heat data collection**, management, analysis and **visualization**.

4. To develop **GIS-based routines** for the integration of **multi-scale** urban structure, cover and fabric data – across cell, facet, element, canyon, block, precinct and city-scales.

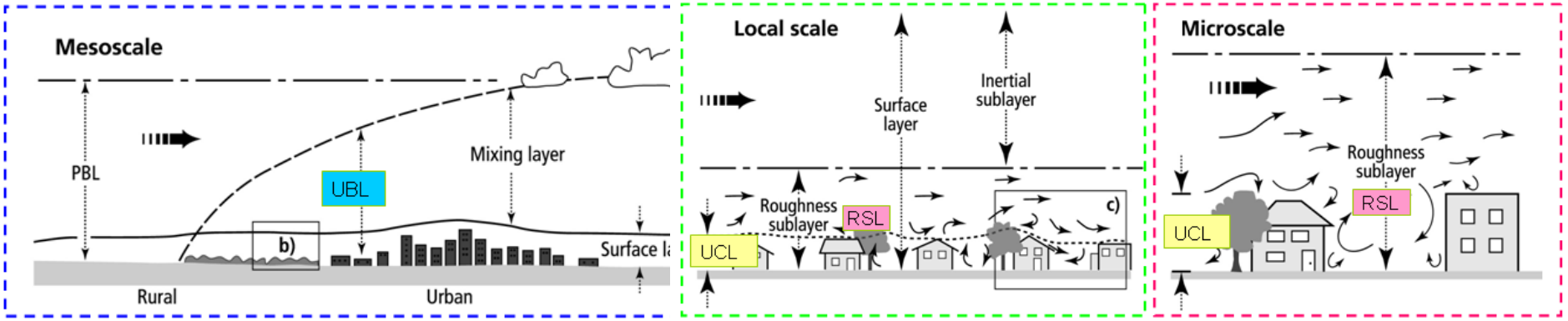


Image: Cleugh and Grimmond 2012



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# Research Questions

1. What are the **material properties** and **spatial configurations** of building facades that dominate outdoor microclimate – represented by surface, air and mean radiant temperatures?

2. What are the **key interactions** between building facade and canyon-scale microclimate parameters (e.g. canyon aspect ratio, sky-view factor, etc.)?

3. What observation methods, sensors and equipment, data platforms and auxiliary datasets are optimal for ground-based, in-situ urban observations and analysis?

4. What typology (spatial classification system) is suitable to describe facade thermal behaviour?

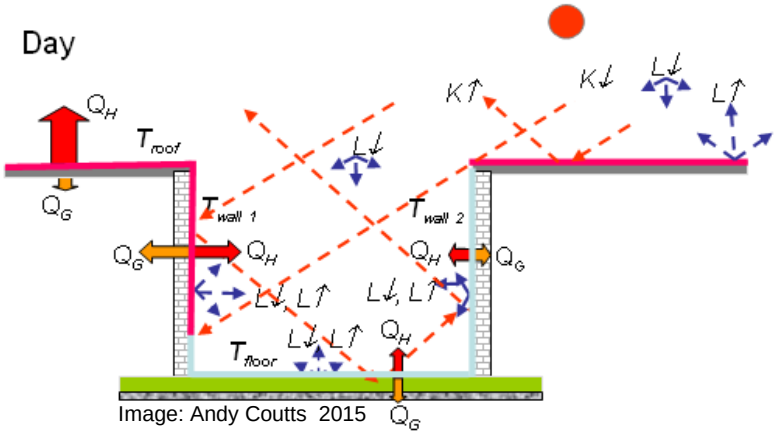
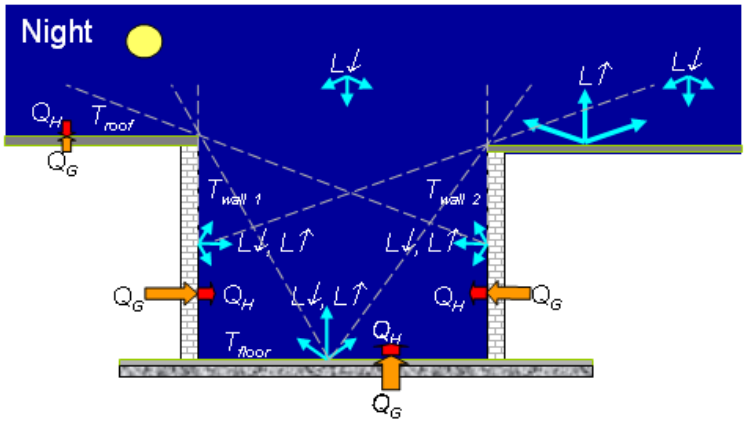



Image: Andy Coutts 2015



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# Research Framework (data collection)

| Variables | Platform | Sensors and Instruments |
|---|---|---|
| Meteorological parameters |  | • 3 x net radiometers (Hukseflux NR01)<br>• 40mm GG thermometer (Pt100/RAL7001, ± 0.05°C )<br>• 3-axis ultrasonic anemometer (Gill WindMaster)<br>• Shielded temp and RH sensor (Rotronic HCS3, ± 0.1°C )<br>• Barometric pressure sensor (Vaisala PTB 110)<br>• Pyrano-albedometer (Middleton Solar SK16) |
| Thermal |  | • FLIR B335, f = 10mm, 45º (IFOV: 2.59 mrad/pixel)<br>• IR resolution 320 x 240 pixels (DC 2048 x 1536)<br>• FPA uncooled microbolometer: 7.5 – 13µm<br>• IR accuracy: ±2°C or 2% of reading<br>• IR sensitivity: 0.05°C @ +30°C |
| Spectral albedo |  | • Tetracam ADC multispectral camera<br>• 3.2 megapixel CMOS sensor 2048 x 1536 pixels<br>• 3 wavebands 0.52-0.90µm (Red: 0.52 - 0.60µm: Green: 0.63 - 0.69µm; NIR 0.76 - 0.90µm)<br>• f = 8mm (IFOV: 0.54 mrad/pixel) |



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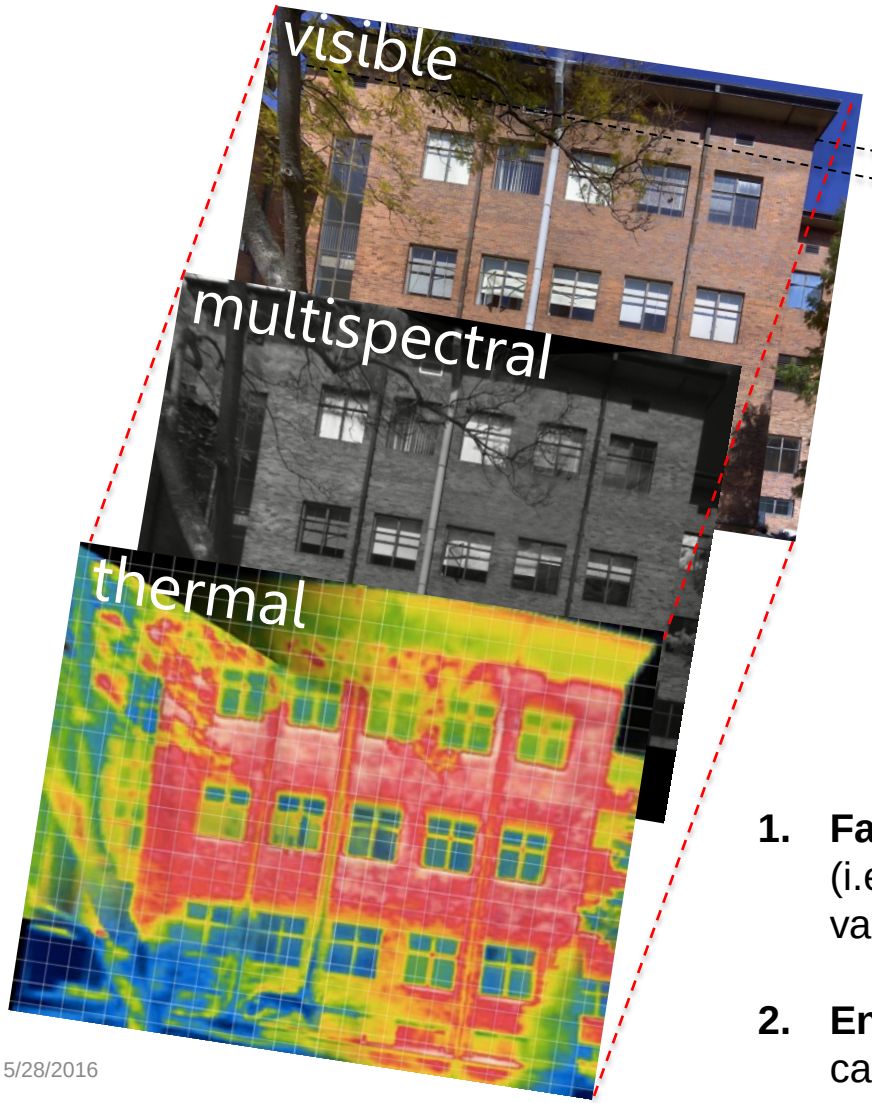
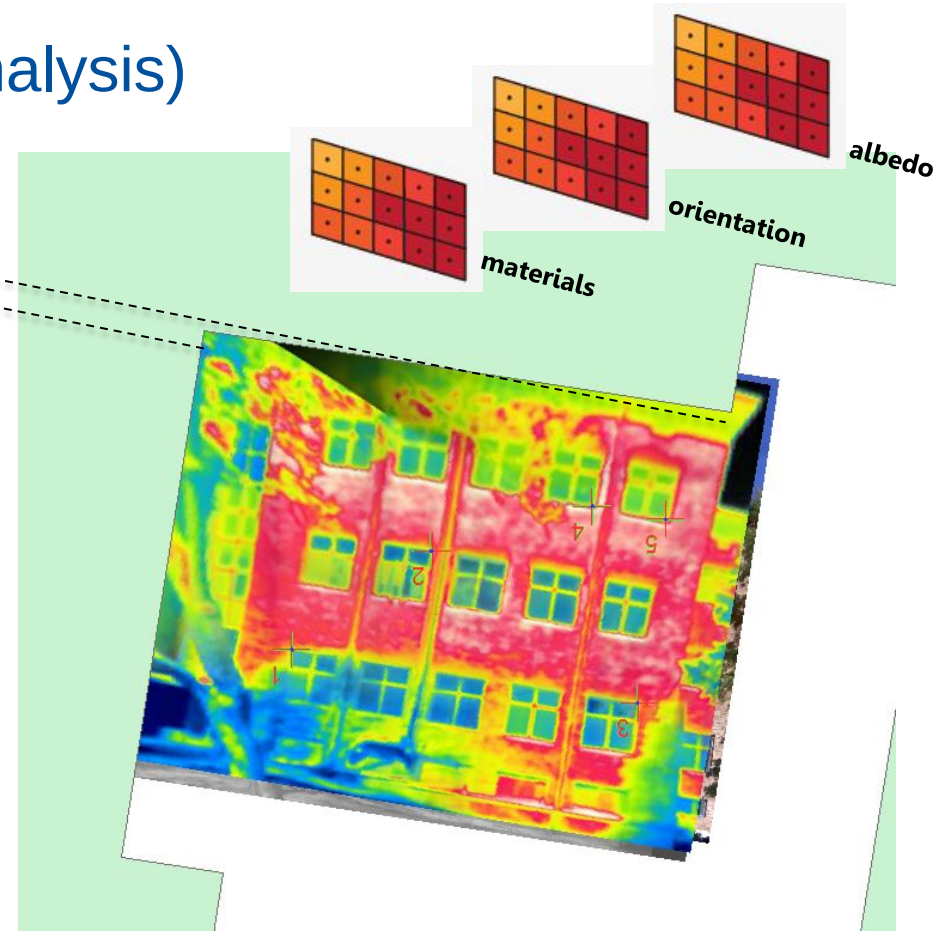
# Research Framework (data analysis)




1. **Facet model** – image analysis per discrete facade (i.e., cell statistics, datasets of independent variables and $T_{Surface}$ regression model)

2. **Ensemble model** – $T_{S1-n}$ plus OTC datasets plus canyon geometry parameters



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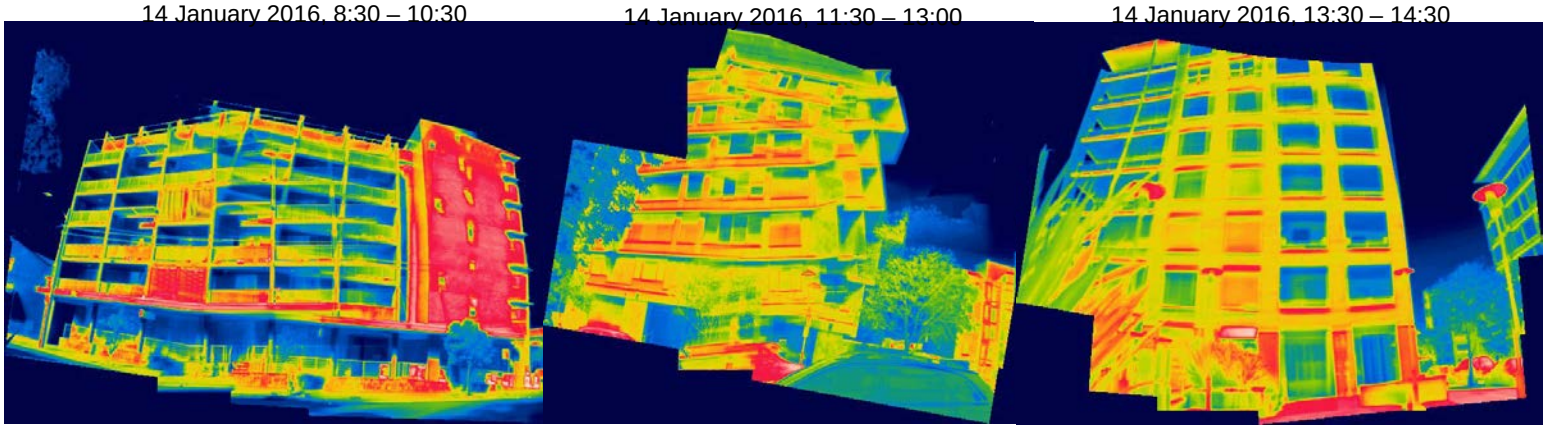
# Research Challenges

| | Workflow | Tool | Output | Challenges |
|---|---|---|---|---|
| 1 | Raw data collection | Sensors | Raw data | Sensors, suitable facades, weather, people, cars…. |
| 2 | Per-pixel temperature data extraction | FLIR IR | .csv temperature file (table) | Per-image only (not mosaic) |
| 3 | Single-band (RGB) raster creation | ArcMap Tools | Raster dataset with per-cell RGB values | Noise and non-linearity |
| 4 | Temperature to RGB correlation model | SPSS | Linear regression equation | Robust Ad.$R^2$ |
| 5 | Orthomosaicing and georeferencing | Photogrammetry/ ArcMap | Plane rectified mosaic | Dimensions/base -maps |
| 6 | Thermal, radiative and canyon structure corrections – SEB | $Q^* = K\downarrow - K\uparrow + L\downarrow + L\uparrow$<br>$Q^* = (1-\alpha_s)K\downarrow + (1-\epsilon_s)L\downarrow + \epsilon_s\sigma T_s^4$ | Temperature adjustment matrix | **Complicated!** |

# Outcomes/Innovation/Impacts

1. Architectural “pattern book” of vertical-surface thermal typologies (VeSTT)
2. Development assessment framework for urban heat mitigation at the building scale
3. Contribution to major gap in urban climatology – **the role of facades in the SEB**
4. Part of the urban analytics/infomatics, “smartcity” discourse – using urban thermal and meteorological data to support sustainable cities





Site 21 Wattle St Ultimo


Site 22 Point St Pyrmont


Site 23 Point St Pyrmont



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