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## **Towards Context & Climate Sensitive Urban Design An integrated simulation and parametric design approach**

Aymeric Delmas, Michael Donn, Virginie Grosdemouge, Marjorie Musy,  
François Garde

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# Towards Context & Climate Sensitive Urban Design

## An integrated simulation and parametric design approach

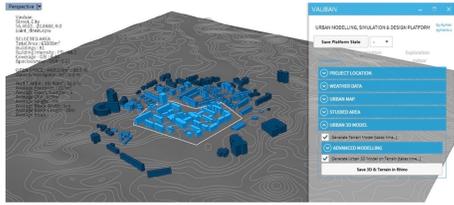
**Aymeric DELMAS**  
 PHD Candidate at PIMENT 1/CRENAU 2, Research Engineer at IMAGEEN  
 aymeric.delmás@imageen.re  
 Michael Donn 3, Virginie Grosdemouge 1, Marjorie Musy 4 and François Garde 1  
 1 PIMENT - Le Tampon, 97430, Reunion Island  
 2 CRENAU - Nantes, 44000, France  
 3 School of Architecture VUW - Wellington, 6140, New Zealand  
 4 CEREMA Ouest - Nantes, 44000, France



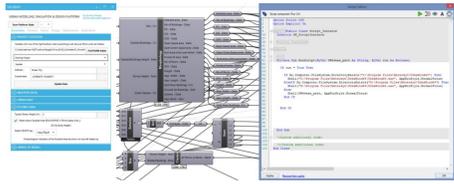
### DESIGN PLATFORM & FRAMEWORK

#### Supporting urban bioclimatic design

To implement the concept of integrated design, an urban **modelling, simulation and design** platform was developed. It embeds a design framework built upon the strengths of **parametric modelling** and existing **building performance simulation tools**.

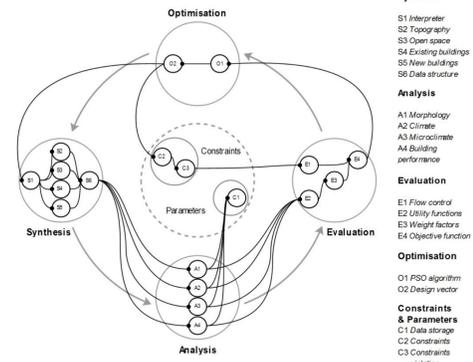


**Platform overview**  
 Rhino's viewport integrated user interface and urban 3D model



**Platform levels of transparency**  
 User interface, directed acyclic graph and textual code

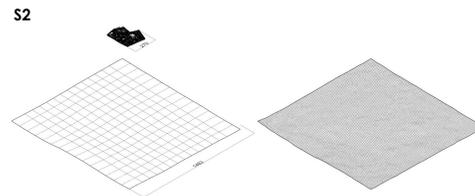
The **centralisation** of the synthesis, analysis, evaluation and optimisation **activities** in a single interface helps to support the integrated design concept. Data exchange and treatment allow **informing** both the simulation tools and the design process in terms of context and climate consideration.



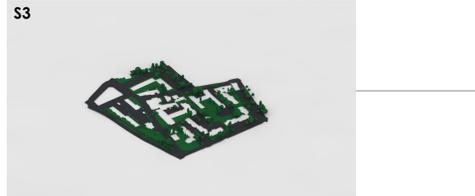
**Design framework**  
 The context and climate sensitive urban design framework

### SYNTHESIS

#### Parametric generation of the urban environment



**Topography**  
 A sampling script allows matching measured elevation (3m grid) of the studied area with larger satellite elevation of the surrounding terrain (SRTM 30m grid)



**Open spaces & natural elements**  
 are modelled based on measurements (or GIS data) of their boundaries. Trees are modelled as ovoids based on surveyed characteristics (height, width, density)

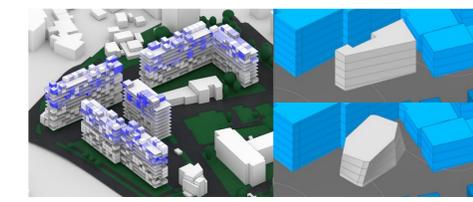


**Buildings**  
 are modelled based on their footprints and heights. Surrounding buildings of the area of interest are selected based on height and distance criteria

The parametric modelling capacities of the software pair Rhinoceros-Grasshopper are used to generate a synthesis model of **interrelated urban elements**. Topography, buildings, open spaces and natural elements are connected with each other in an algorithmic relation.



**Combined urban 3D model**  
 Vauban neighbourhood, case study located in St-Denis, La Réunion

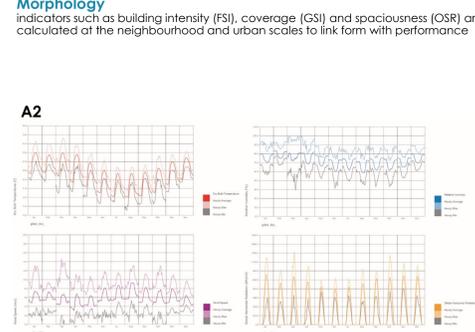
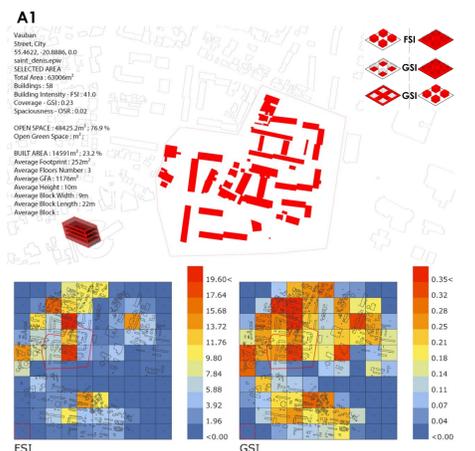


**Bioclimatic strategies & new building blocks**  
 Generative definitions of context sensitive blocks and urban interventions are integrated and can be optimised

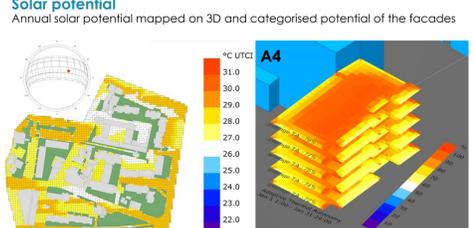
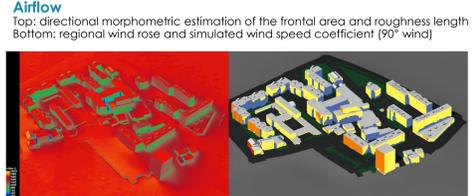
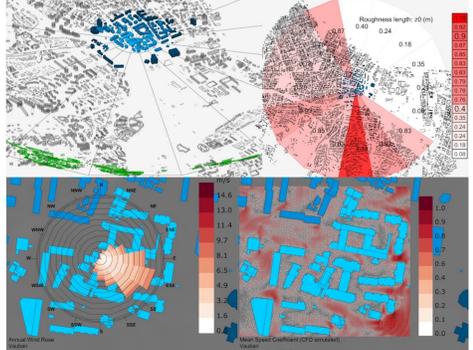
### ANALYSIS

#### & simulation of the outdoor and indoor conditions

The **complex relationships** between **form** and **environmental performance** are analysed thanks to several mathematical models with different level of fidelity. All analysis models use the unique parametric synthesis urban model so that any **morphological, topological** or data change will influence the whole data.



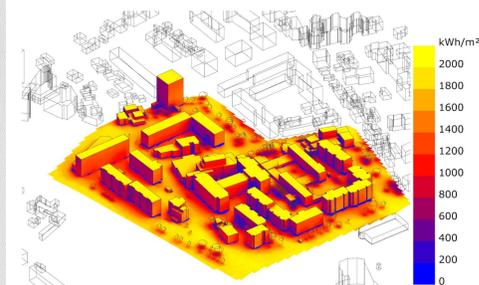
The **dynamics of the urban microclimate** and its effects on outdoor and indoor conditions is captured by using **specific simulation tools** (UrbaWind for the CFD airflow, Radiance for solar irradiation, EnergyPlus for indoor and outdoor thermal conditions)



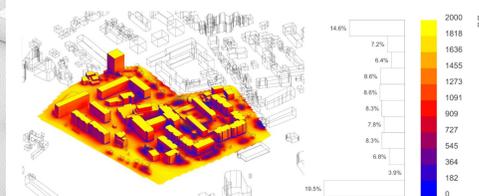
### PARAMETRIC STUDY

#### Impact of modelling simplification on solar potential

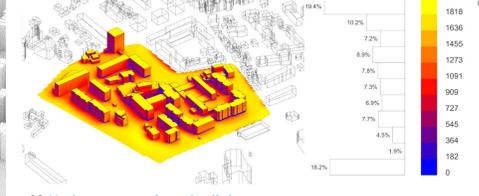
The **parametric generation** of the urban environment and its constitutive elements allows running similar simulation with various scenarios. Here the most detailed 3D model is simplified gradually to assess the **impact of each modelling scenario on the solar potential of more detailed ones**.



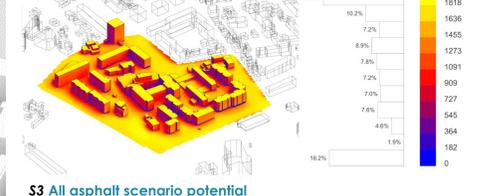
**DS Detailed scenario solar potential**  
 Basements of buildings are not studied and so have a null potential



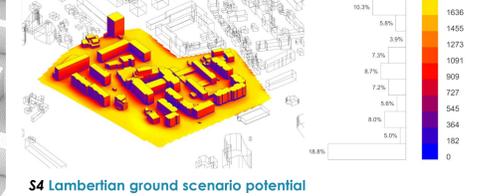
**S1 Spherical trees scenario potential**



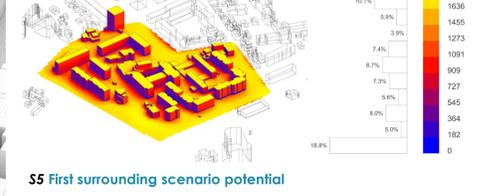
**S2 No trees scenario potential**



**S3 All asphalt scenario potential**



**S4 Lambertian ground scenario potential**



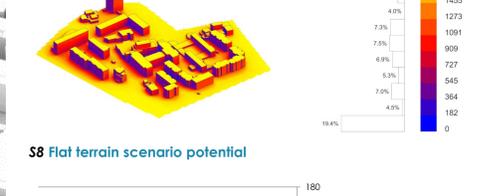
**S5 First surrounding scenario potential**



**S6 No surrounding scenario potential**



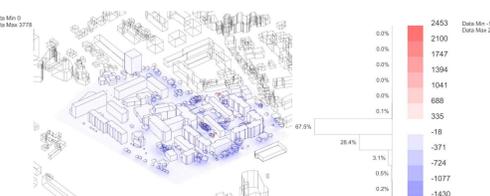
**S7 Unsimplified terrain scenario potential**



**S8 Flat terrain scenario potential**

| Radiance parameters     | ab=2, ad=1000, as=16, ar=98, grid size=1m   |
|-------------------------|---|
| DS Detailed scenario    | Ovoid trees, detailed ground materials distribution (asphalt/grass), extended surrounding, sampled topography |
| S1 Spherical trees      | DS with simple trees instead of ovoid trees   |
| S2 No trees             | S1 with trees removed   |
| S3 All asphalt          | S2 with all asphalt ground instead of the asphalt/grass distribution  |
| S4 Lambertian ground    | S3 with 20% reflective lambertian ground instead of all asphalt   |
| S5 First surrounding    | S4 with extended surrounding removed, only first radius of surrounding buildings kept                         |
| S6 No surrounding       | S5 with no surrounding buildings  |
| S7 Unsimplified terrain | S6 with SRTM (30m precision) terrain instead of 3m sampled terrain  |
| S8 Flat terrain         | S7 with flat terrain instead of SRTM terrain  |

**Radiance and geometric parameters of the simulated scenarios**



**DS - DS Absolute potential difference**



**S1 - DS Absolute potential difference**



**S2 - S1 Absolute potential difference**



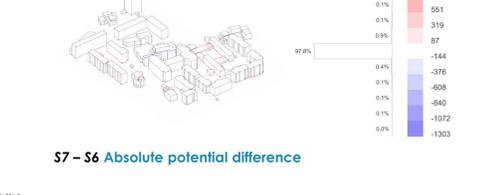
**S3 - S2 Absolute potential difference**



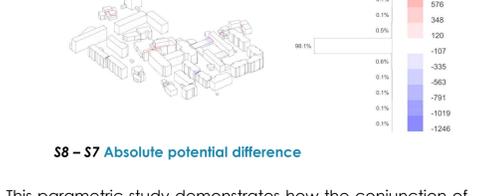
**S4 - S3 Absolute potential difference**



**S5 - S4 Absolute potential difference**



**S6 - S5 Absolute potential difference**



**S7 - S6 Absolute potential difference**

This parametric study demonstrates how the conjunction of simulation and parametric modelling can **inform** a digital design process with **precise mapping of microclimatic conditions**. Here the link between form, materiality and solar potential is sequentially represented and shows the importance of modelling practice. From this case, the integration of **trees** and appropriate **ground material** could represent **significant strategies to reduce the local UHI effects** due to solar collection.

**DS to S8 Total solar potential evolution**