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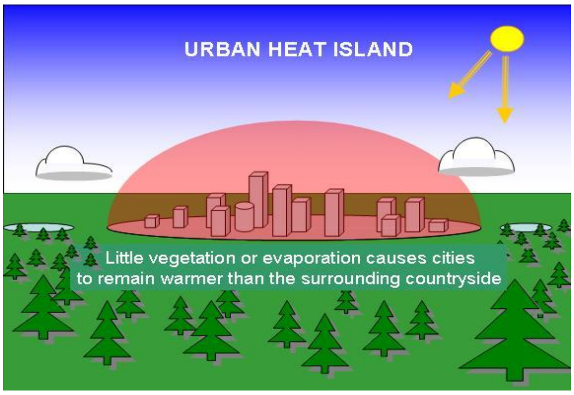
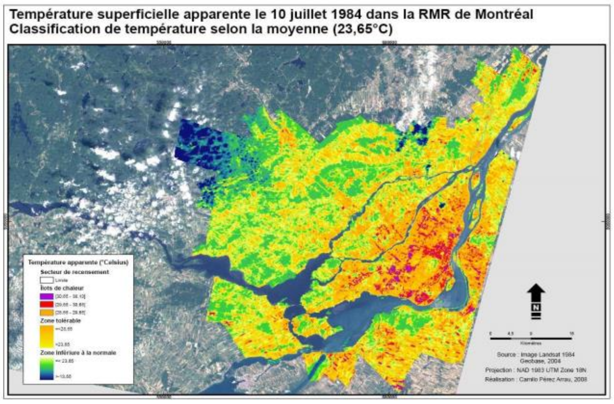
Prototype Heat Island Application

PHOENICS Case Study - Environmental





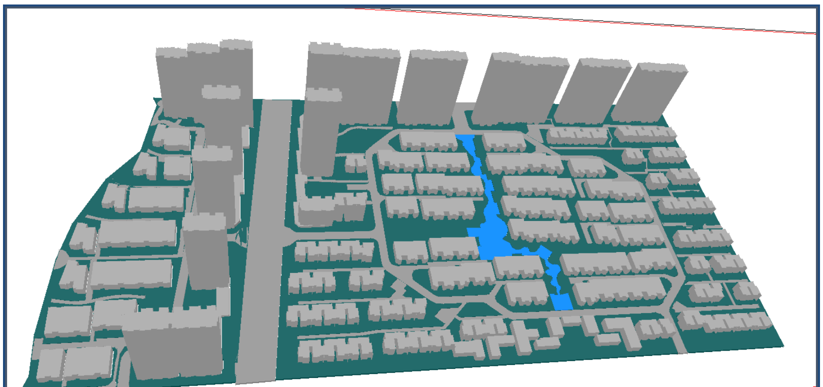
Introduction

Heat islands are large-scale phenomena in which the general urban temperature level rises above that of the rural surroundings. The main cause of the heat-island effect is the absorption by and emission of radiation by hard-surfaced man-made objects (buildings and roads). The sun falls on vegetation and on cities at the same rate; but the vegetation absorbs the incoming radiation in depth, is better cooled by the air in which it is immersed and can lose heat by evaporation. Hard surfaces by contrast quickly attain the temperatures which enable them to emit nearly as much radiant heat as they gain (the difference being lost by convection).

Unlike the large-scale Air Ventilation Assessment (AVA), heat island simulation does not require that the detailed geometry of buildings be captured; rather it is the amount of solid surface per unit volume, and its emissivity, which is decisive. The 'sun' object in PHOENICS can compute the intensity and direction of incoming radiation and its distribution upon surfaces, and the Immersol feature is ideally suited to handling the redistribution of radiation between buildings by reflection and re-radiation.

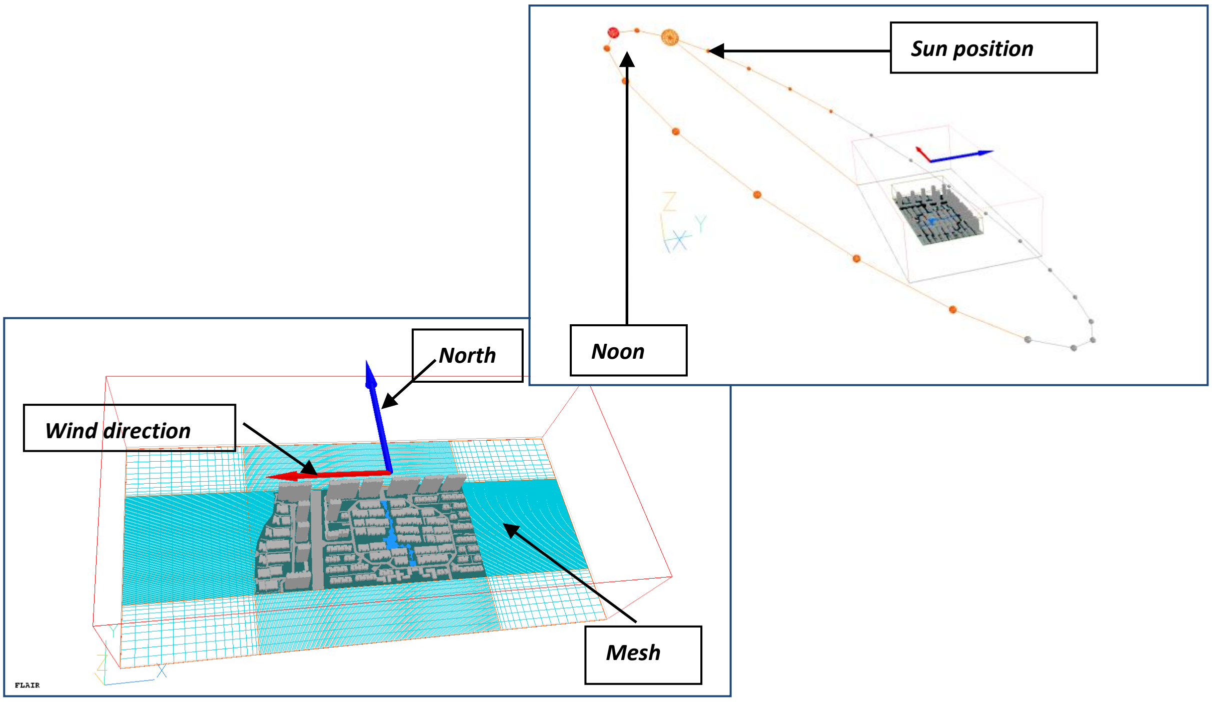
To date, little simulation of heat island phenomena has taken place. However, investigation into heat islands, their causes and effects, is becoming an increasingly important across the globe, especially, as one might expect, in highly urbanised environments.

A new PHOENICS-based prototype heat island model has been developed in response to that demand and forms a flexible template for the investigative engineer to use.



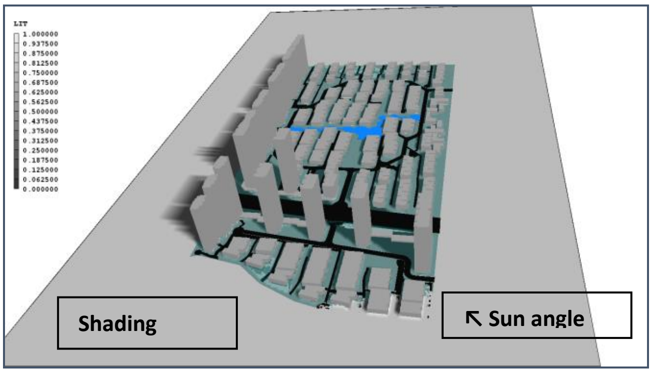
Geometry – comprising buildings, roads, hard ground, grass and water way

The idealised geometry shown above contains many of the components of interest to the "Heatisle" engineer; viz, concrete and glass high rise buildings, tarmac roadways, hard terrain and vegetation, and a water course. Each component responds differently to solar radiation.



In the hypothetical 'test' case, wind and sun conditions represent the UK (at Gatwick) in April.

- Wind direction: East
- Wind speed: 2.5 m/s at 10m
- Logarithmic wind profile
- Roughness height: 0.1m
- Ambient temperature: 12˚C
- Ground temperature: 9˚C
- Sun latitude: 51deg
- Direct radiation: 400 W/m2
- Diffuse radiation: 100 W/m2



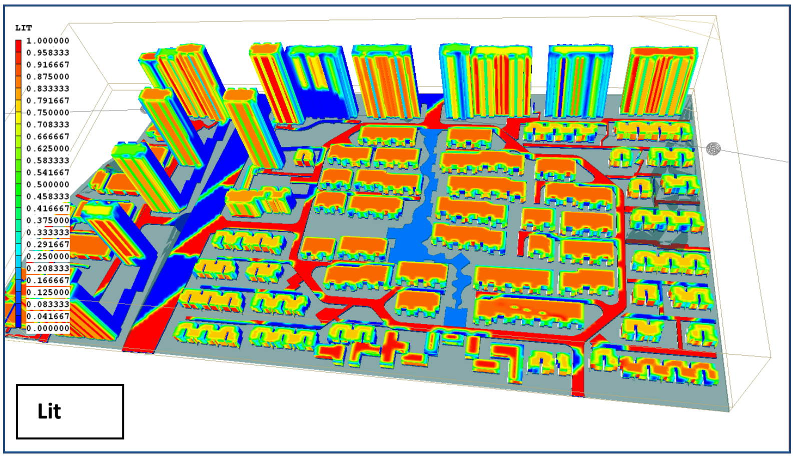
In this example, the ground surrounding the buildings, road, grass and river all have a Z depth of 2m. The ground temperature of 9˚C is applied at the lower face of the ground. This represents the constant earth temperature underground.

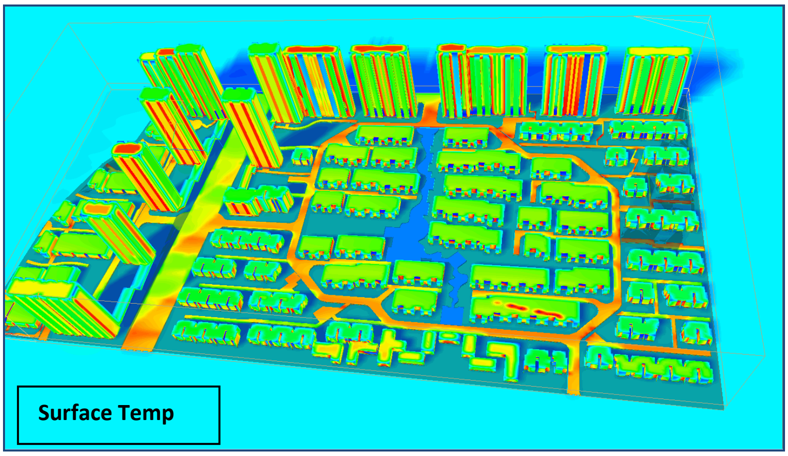
The radiative heat transfer is handled by IMMERSOL. The surface emissivities are set as per the table:

Radiative heat loss to the sky is represented by a radiative heat loss to an external temperature of -2˚C with an emissivity of 1.0.

Ground:	0.9
Grass:	1.0
Road:	0.5
River:	1.0
Building:	1.0

Although in this case the model is set with user-defined inputs, both the sun and wind parameters can be imported from an EPW weather file (eg the public domain Energy Plus database.)





Conclusion

The prototype heat-island module successfully demonstrates the ability of PHOENICS to simulate processes of this type. Whilst there is already connectivity with weather mapping data bases, the module relies on the user to specify appropriate materials, their emissivity and their absorptivity values.

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