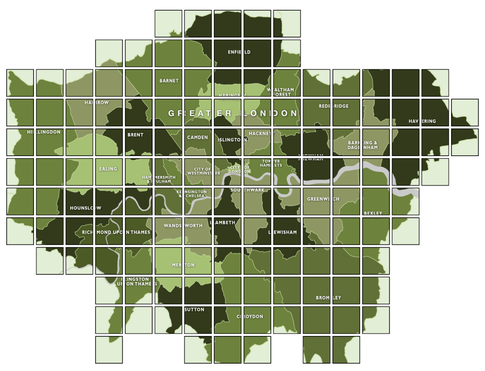
Finding common ground: A framework for city-scale underground climate change modelling

CSIC Cambridge Centre for Smart Infrastructure & Construction

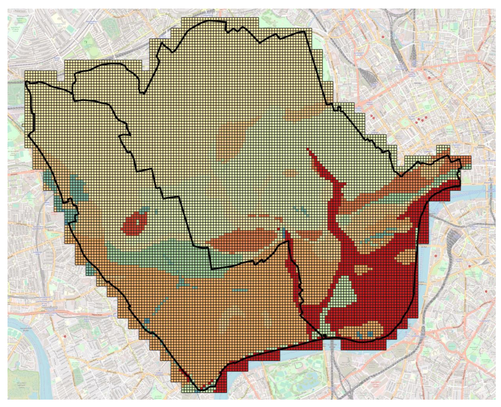
Anthropogenic infrastructures, such as tunnels and heated basements, are known to raise urban subsurface temperatures, affecting the surrounding environment and presenting an underused shallow geothermal resource. To utilise this effectively and fairly, large-scale thermal modelling of the shallow subsurface is necessary to account for thermal interactions between deployed geothermal technologies. However, modelling at such scale is prohibitively computationally expensive. This work proposes an extendable archetype-based framework to address this, presented below. Having performed this for a city, the identified archetype catalogue can be used in other locations with similar features, and more archetypes can be added to the catalogue to extend the applicability of the framework, thereby being able to generate a thermal map for any location without additional modelling.

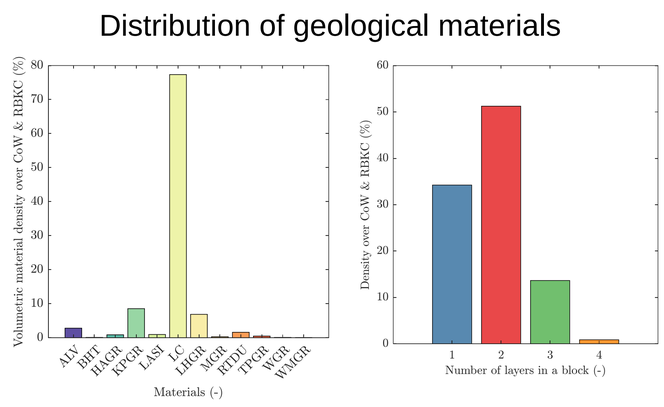
Framework

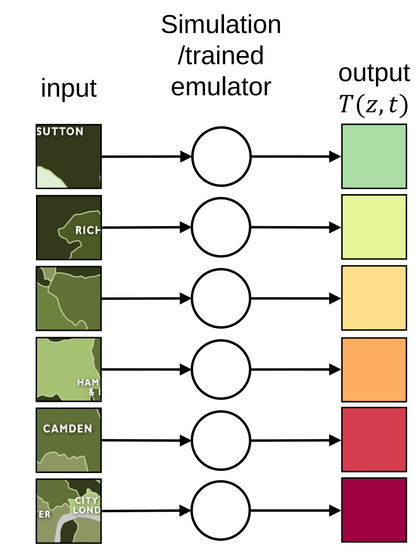


Divide

Divide city-scale area into blocks of pre-defined volume and **find common features to define archetypes**. Features are based include hydro-geological properties, surface cover, presence of anthropogenic structures, groundwater flow, etc.

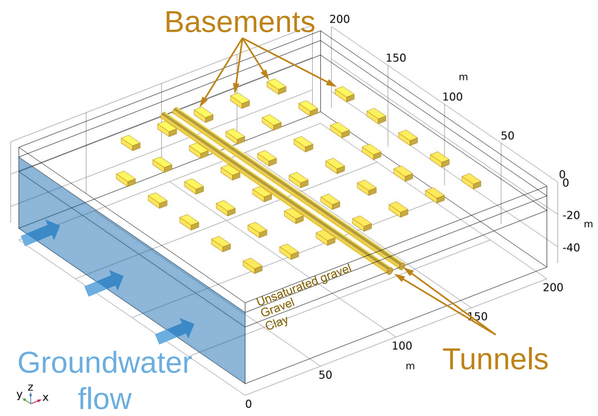


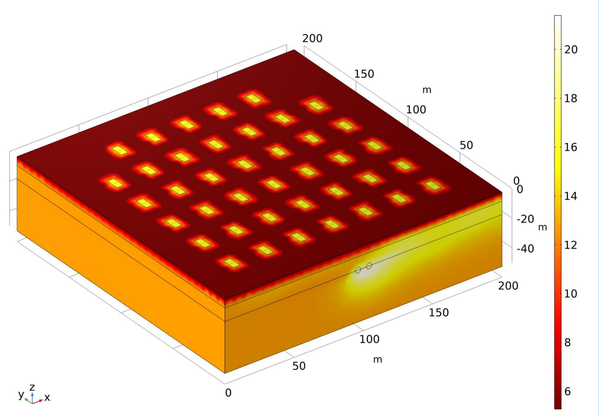


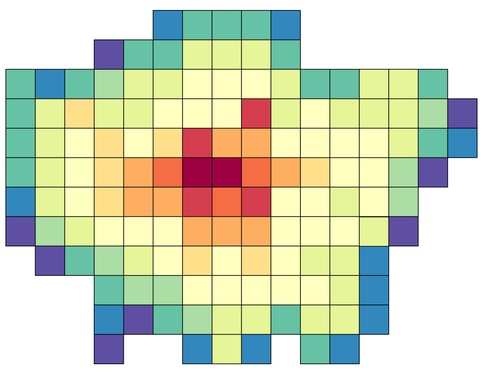


Compute

For each block, if the contained combination of features correspond to a previously defined archetype, use existing input-output data from archetype catalogue. Otherwise **simulate the presented scenario** and add output to catalogue.

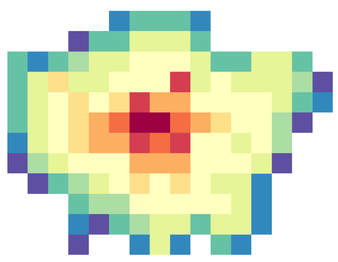




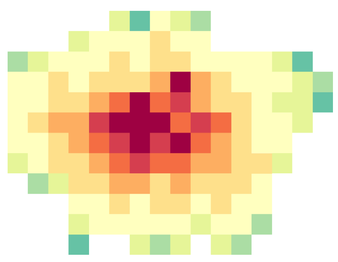


Combine

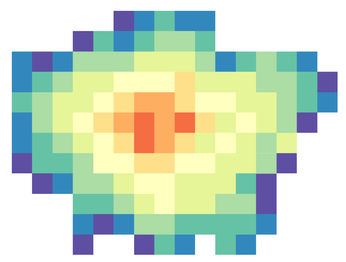
Merge outputs from each block to generate a city-scale underground thermal map. Possible to create future scenarios for next X years to allow **future scenario modelling** by incorporating different archetypes and slotting them in.



Base case (current predicted scenario)



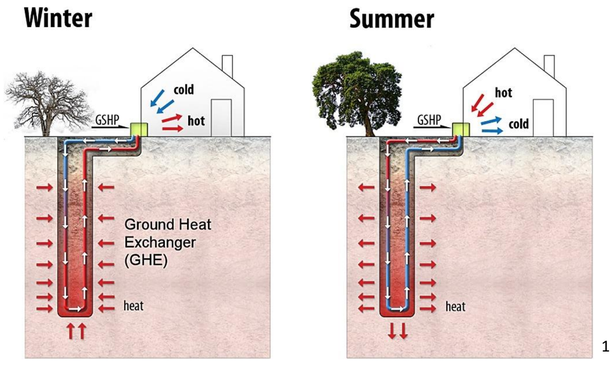
Unregulated construction into the shallow subsurface



Regulated geothermal deployment, mitigating temperature increase

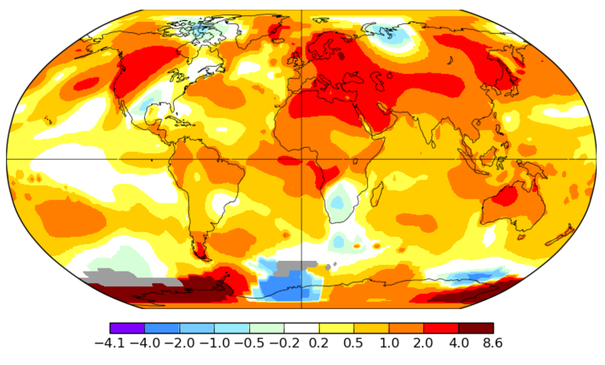
Applications

Efficient utilisation of shallow geothermal energy resources



1

Underground climate change forecasting



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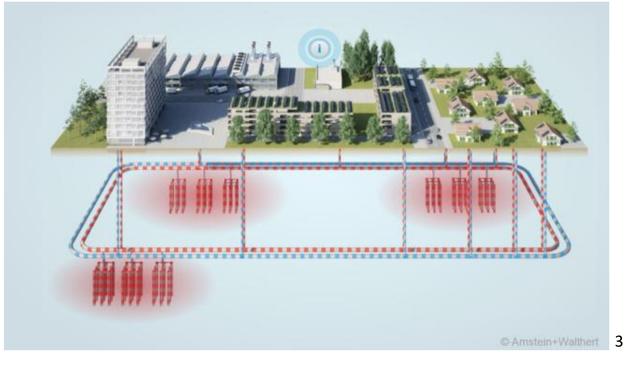
Urban planning: sustainable and fair use of the ground



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Sources: 1) Johnston, I.W. and Narsilio, G.A., 2014; 2) NASA, 2020; 3) CERN, 2019

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