Using the Urban Tethys-Chloris (UT&C) model to estimate the surface energy and water balance of different garden materials and configurations

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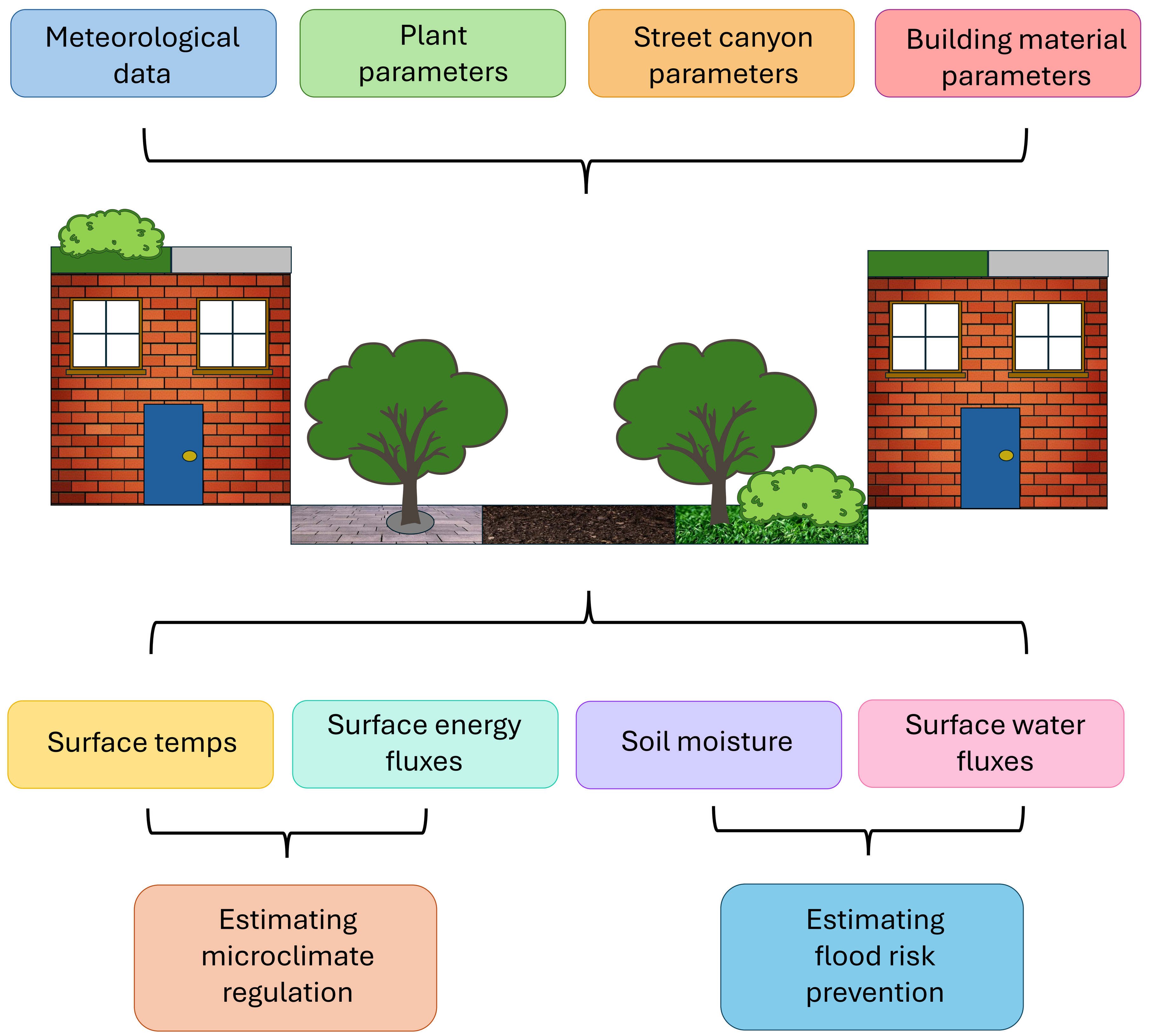
Scenario DOCTORAL TRAINING PARTNERSHIP | RHS | University of Reading

1) Introduction

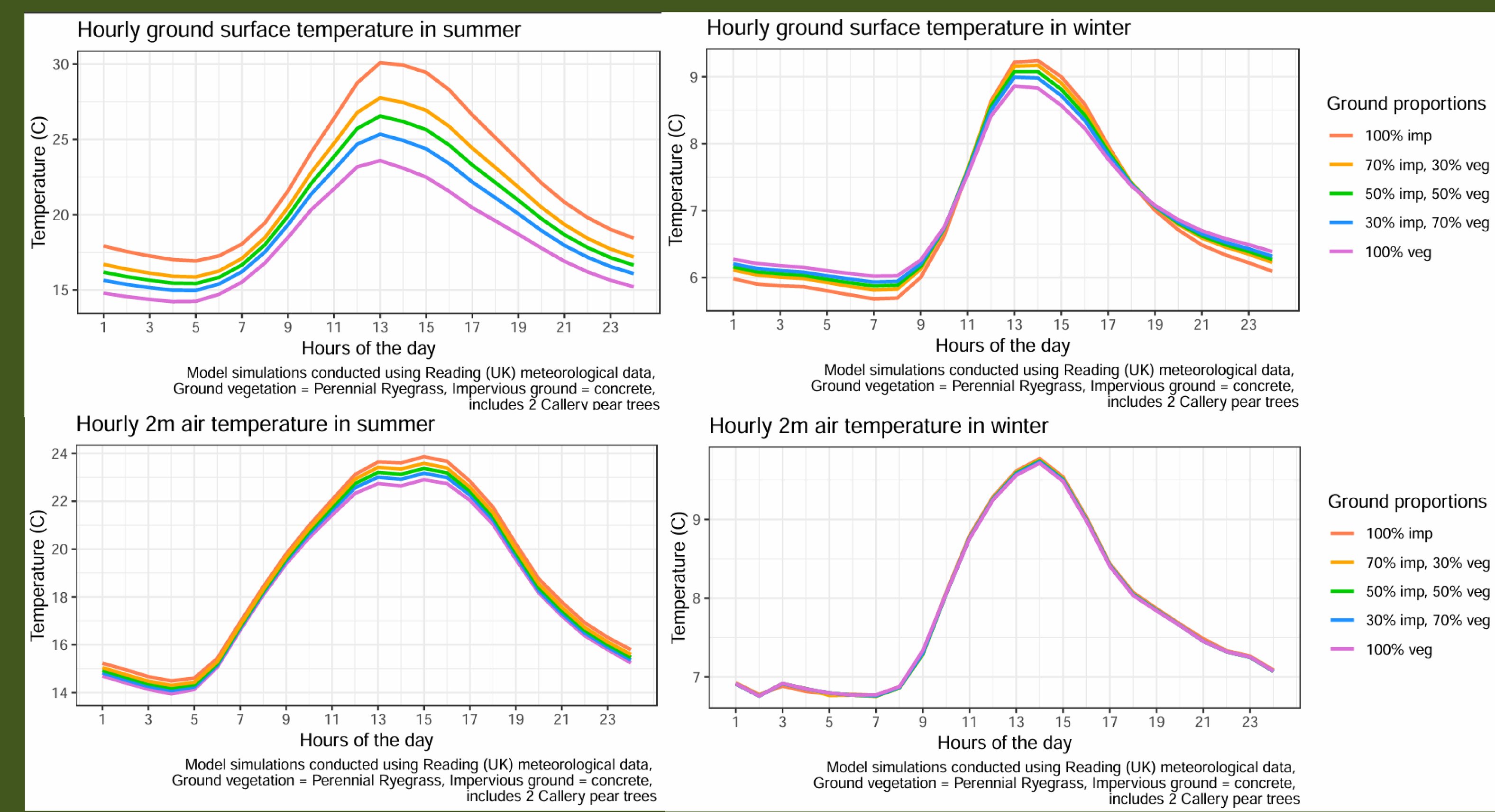
- **Domestic gardens** make up to 30% of UK urban areas
  - → **Plant choice and garden management** influence delivery of **ecosystem services (ES)** such as microclimate regulation and flood prevention
- **Urban land surface models** can be used to estimate ES provisioning
  - → Current estimates of ES in **urban areas** often **omit domestic gardens**
  - → This could lead to unreliable recommendations
- **Urban Tethys-Chloris (UT&C)** was chosen to assess ES of UK gardens as it:
  1. Is configurable for the **local scale**
  2. Includes **both vegetated** and **urban land**
  3. Calculates both the **surface energy** and **water balance**

2) UT&C methods



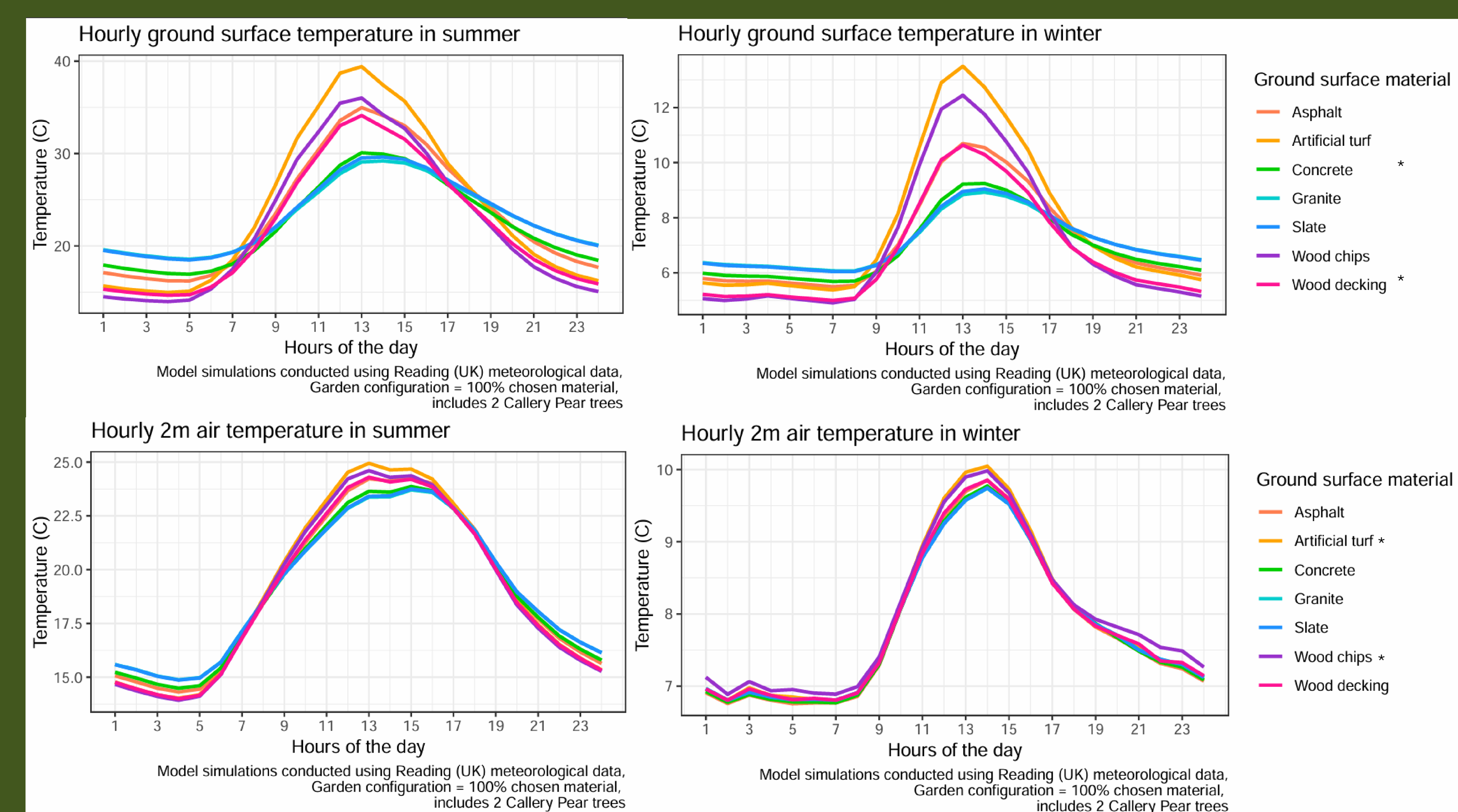
3) Results: Energy Balance (EB)

Effect of Garden Surface Proportions on Temperatures



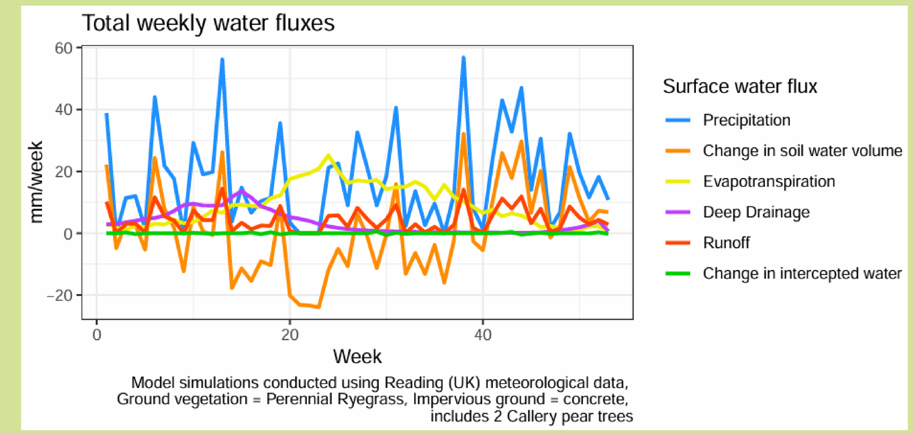
- In the summer, compared to a garden made of 100% concrete, a garden made of **100% vegetation** has a peak surface temperature and peak 2m air temperature that are **13°C and 1°C cooler**, respectively
  - → This is due to **vegetated gardens losing more heat through latent heat flux** throughout the growing period, while impermeable surfaces can only do so after heavy rainfall

Effect of Garden Surface Materials on Temperatures

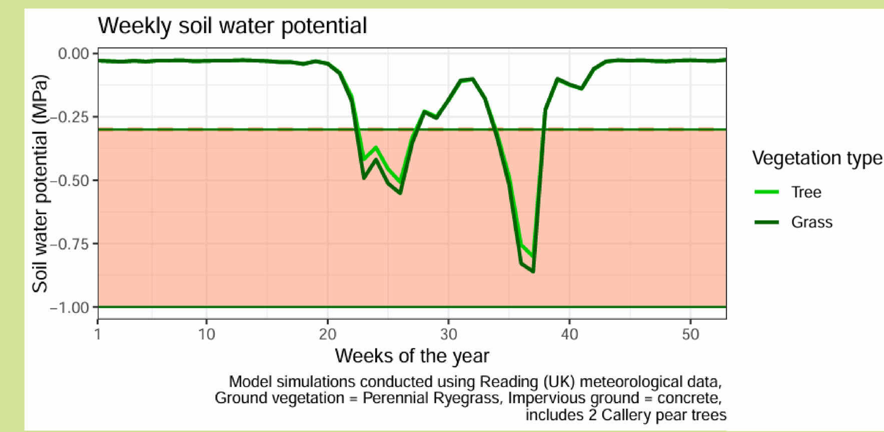


- In the summer, gardens made of **granite, concrete** and **slate** have a peak surface temperature up to **10°C** and 2m air temperature up to **1.25°C cooler** than other **impermeable and semi-permeable (*) materials**
  - → This is due to these impermeable surfaces having a **higher thermal conductivity** and **volumetric heat capacity**, as well as the ability to hold water on their surface to allow the occurrence of **latent heat flux** and **related cooling**

3) Results: Water Balance (WB)



- For this model configuration, the perennial ryegrass lawn is **water stressed** from 29/05/23 – 09/07/23 and 21/08/23 – 24/09/23, and shows **reduced evapotranspiration** rates in response
  - → This is because perennial ryegrass begins to **shut** its **stomata** when soil water potential falls **below -0.3MPa**, lowering its transpiration rate
- Evapotranspiration (and resulting change in soil water volume) shows a relatively smooth **seasonal variation** modulated by **environmental conditions** and **plant growth**, whereas deep drainage, runoff, and change in intercepted water are affected more directly by **precipitation** rate
  - → However, deep drainage (DD) shows a **delay** from spring-time precipitation peaks, due to the **piston effect** – **stored soil water** is **pushed** out of the **bottom** of the (near-) saturated **soil column**. With **root water uptake** dominating in summer, DD becomes negligible



4) Conclusions

- The UT&C model produces **realistic EB** and **WB** results, including **seasonal** and **diurnal fluxes** related to **ES delivery by domestic gardens**, and responding to changes in key model parameters
- Bespoke model simulations and analysis will allow us to offer **better advice** to UK **gardeners** (e.g. on preferred hard landscaping materials, plant species, and garden configurations)

Recommendations:

- Increase the proportion of vegetation in your garden to reduce air temperatures

5) What's next?

1. Continue to study model sensitivity outputs for **water balance**
   - → Estimate **groundwater** flood risk prevention
   - → Estimate vegetation transpiration resilience, to sustain cooling services during drought periods
2. **Translate** model outputs into **human comfort** and groundwater **flood mitigation indices**
3. Use **SUEWS** and **TEB-SurfAtm** models
   - → Can they also be used to estimate ES provisioning?
   - → Conduct a **model intercomparison**

Acknowledgements

Thank you to my PhD supervisors Prof Anne Verhoef, Dr Tijana Blanuša, and Dr Deepa Senapathi for their ongoing support, the Royal Horticultural Society (RHS) for their sponsorship, and SCENARIO (part of the Natural England Research Council (NERC)) for their funding.

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See my abstract: