



VTUF-3D: An urban micro-climate model to assess temperature moderation from increased vegetation and water in urban canyons

Introduction

- ▶ Assessing positive climatic impacts on human thermal comfort (HTC) of Water Sensitive Urban Design (WSUD), through associated increases in vegetation and water in urban areas, requires a suitable modelling tool
- ▶ Observation studies have shown that increased tree cover is effective in promoting positive HTC in urban areas (White et al., 2012).
- ▶ Modelling HTC at a microscale must fully account for both physical and physiological properties of vegetation, as well as the full soil/plant/atmosphere water cycle. No models were found which fulfilled this requirement.
- ▶ The TUF-3D model (Krayenhoff and Voogt, 2007) was modified in a novel way to tile the MAESPA tree model (Duursma and Medlyn, 2012) within the TUF-3D urban canyon and calculate vegetation radiation transmission.
- ▶ The modified model, VTUF-3D, provides parameters of air temperature, surface temperatures, wind, and humidity at a suitable scale to assess HTC (measured by UTCI) in urban canyon simulations.
- ▶ This tool can be used to determine optimal positioning of vegetation to maximize the impact, as well as determining the climate response of each tree and its relative value in urban canyons.

Validations of VTUF-3D

- ▶ Validations compared modelled results to flux observations in Preston (Coutts et al., 2007), HTC observations in Gipps/George St., Melbourne (White et al., 2012), and T_{surf} and UTCI in Lincoln Square, Melbourne (Motazedian, 2015) and found to broadly reproduce their spatial and temporal variations.
- ▶ Ongoing model development aims to further increase predictive accuracy.

Modelling Gipps St. vegetation scenarios with VTUF-3D

- ▶ 5 scenarios for Gipps St. (Figure 1) of 0% trees, 50% trees, existing 100% Gipps St. tree canopy cover, 200%, and 400% trees (configurations, Figure 3) were modelled.
- ▶ UTCI (averaged at 0m height, Figure 2) maximum variations of 1.0°C between Gipps St. 0% tree scenario and 200% trees
- ▶ Canopy temperature differences (Figure 4) range from 0.2°C to 0.4°C.

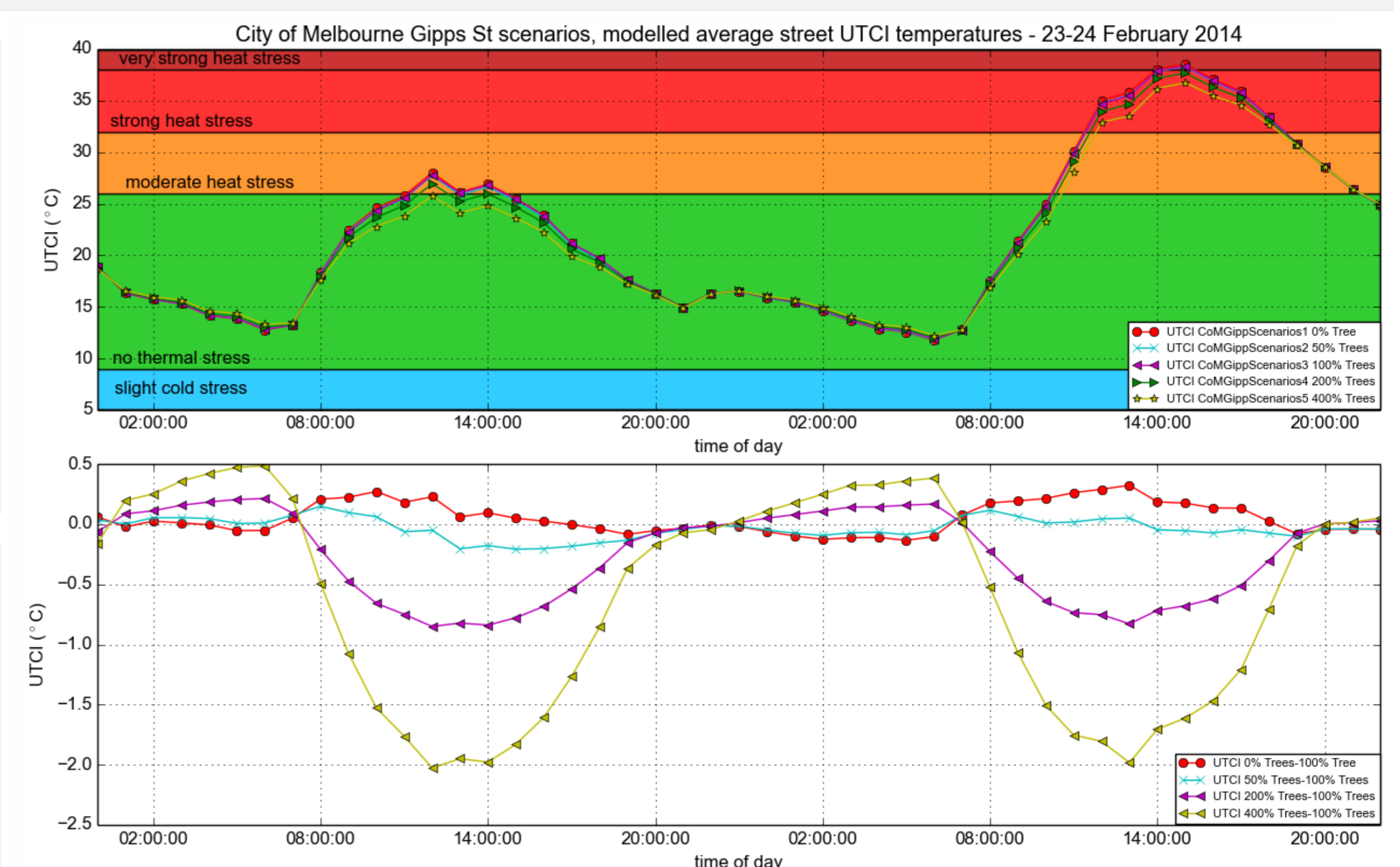


Figure 2: Modelled UTCI of 5 scenarios over 23-24 February 2014 / UTCI differences between 100% trees and other scenarios

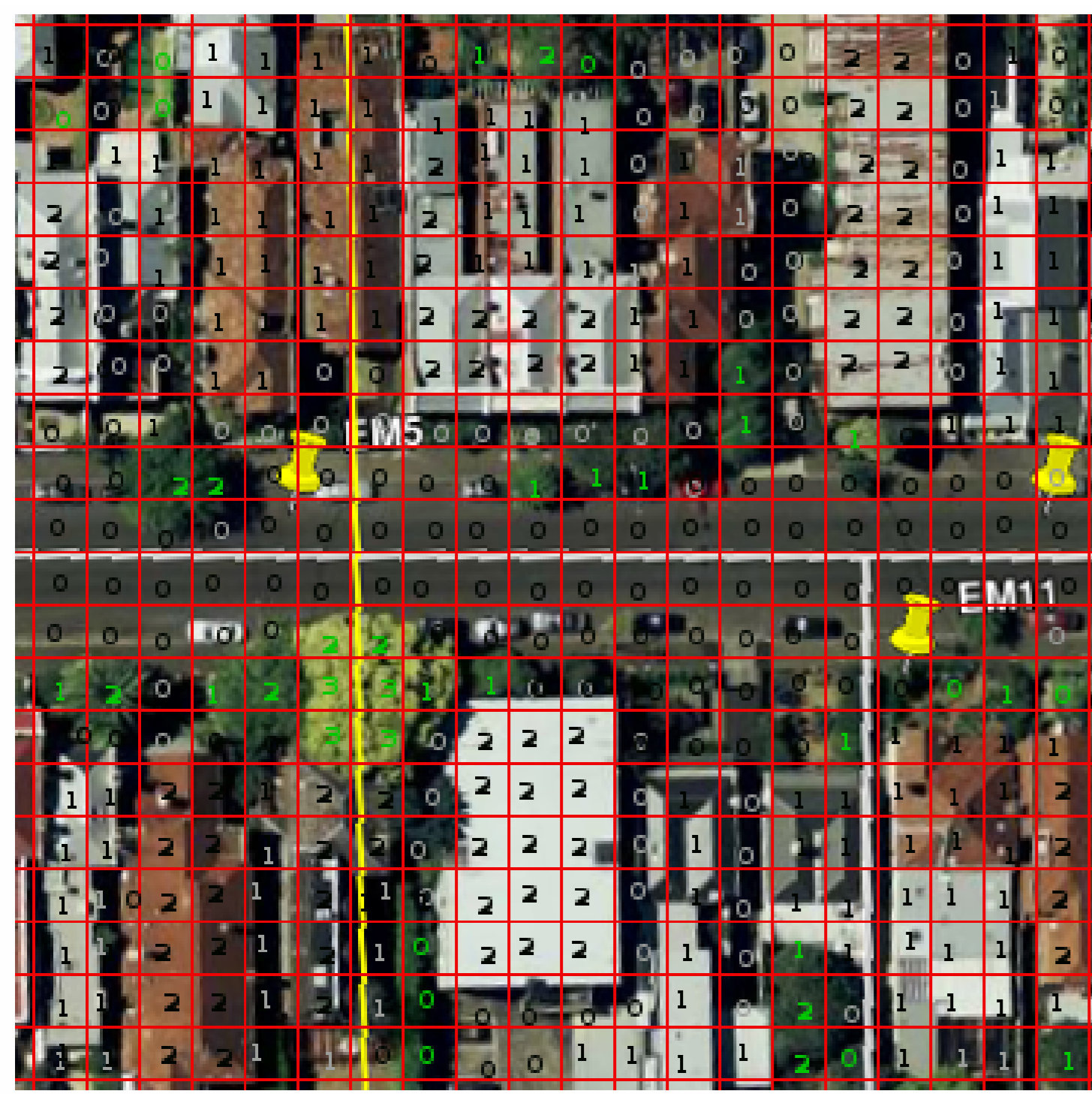


Figure 1: Modelled Melbourne street - Gipps St

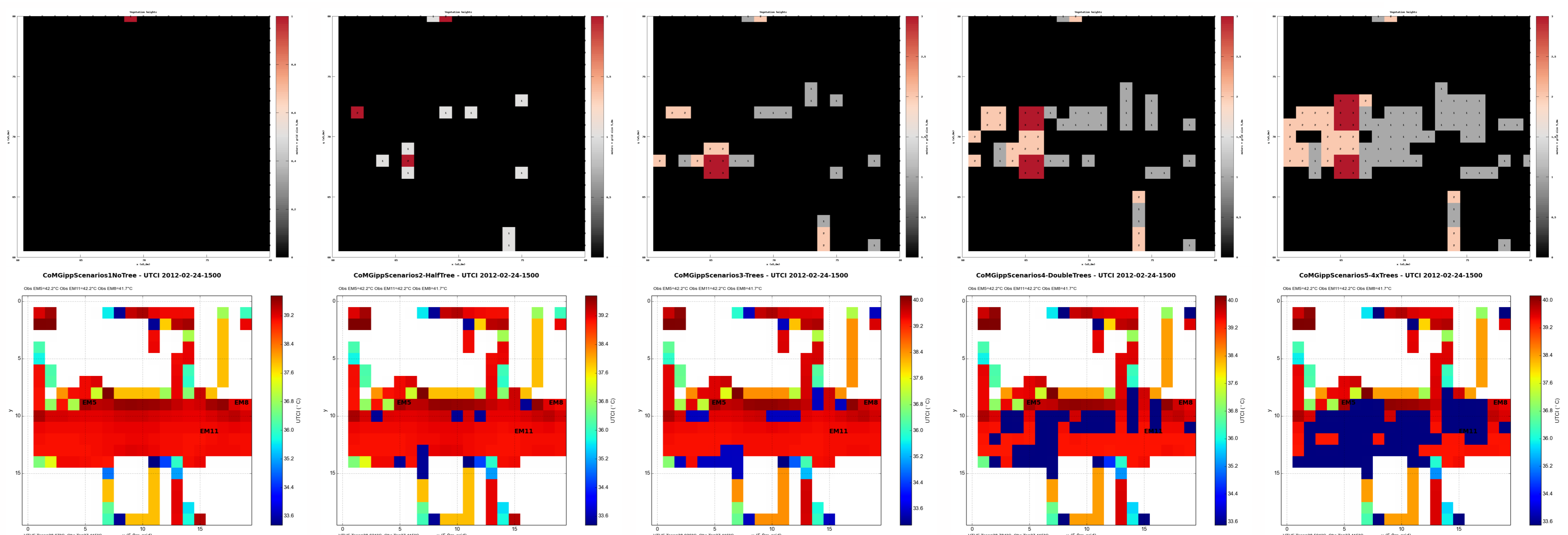


Figure 3: Gipps St. 0%, 50%, 100%, 200%, 400% trees configuration (top)/UTCI at 0m height at 24 Feb 2014 1500 (below)

Conclusions

- ▶ Integration of MAESPA and TUF-3D into VTUF-3D creates a tool suitable to model human thermal comfort impacts of urban vegetation and WSUD at a micro-climate scale.
- ▶ Preliminary modelling with VTUF-3D shows UTCI temperature reductions of up to 1.0°C between varying tree cover scenarios and canopy temperature differences of 0.2°C to 0.4°C.
- ▶ Future tasks include further model refinement to support increased accuracy. Also, modelling of comprehensive sets of WSUD scenarios (analysing tree numbers, height, leaf area, placement and soil moisture) to provide guidelines for optimizing the HTC impacts of increased urban vegetation.

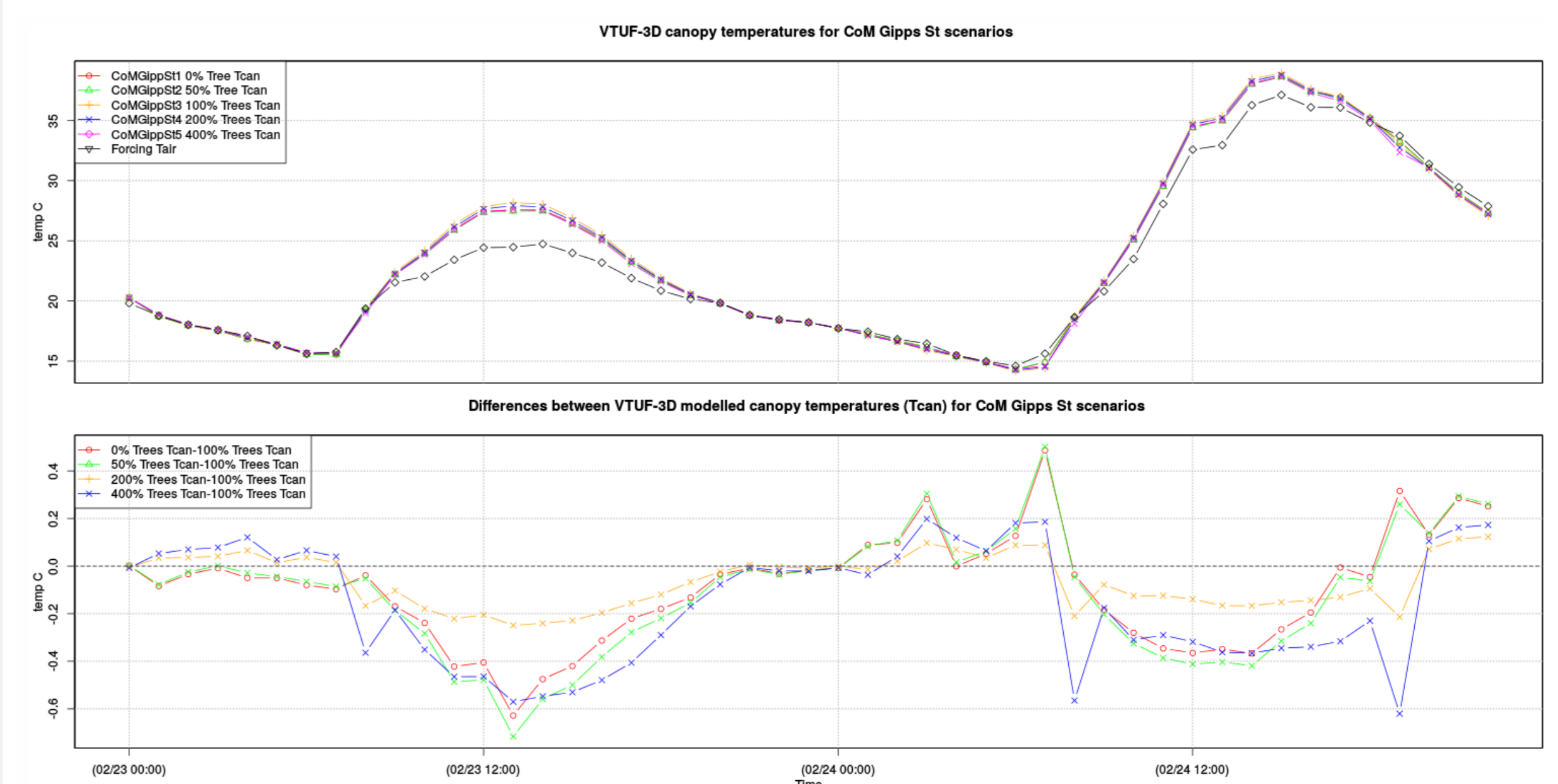


Figure 4: Modelled canopy temperatures of 5 scenarios over 23-24 February 2014 / T_{can} differences between 100% trees and other scenarios