Assessing the microclimate conditions in urban green spaces and the effects of underlying driving factors in Switzerland

The change in local climate poses potential threats to human well-being and health. Urban green spaces (UGS), such as parks and gardens have been recognized as an effective strategy for heat mitigation. The magnitude of the cooling effect of UGS is not only decided by the vegetation itself, but varies across locations, local background climate, and the surrounding urban fabric (Zhao *et al.*, 2014; Xiao *et al.*, 2018; Unal Cilek and Uslu, 2022). The research will answer the following questions: How does the current microclimate vary in different UGS and how do multiple factors drive the difference across Switzerland?

**Case study area**

The selection of case study areas considered the following aspects. Three cities in Switzerland were selected as case study areas, which are Zurich (German, 47°22'N 08°33'E, 408m), Geneva (French, 46°12'N 06°08'E, 375m) and Lugano (Italian, 46°00'N 08°57'E, 273m), considering different biophysical conditions (i.e., bioclimatic region, altitude, urban sociocultural characteristics and language). In each city, five different UGS types were selected that constitute a dominant proportion of the green area in Switzerland: allotment gardens, public parks, private gardens, real estate yards, and ruderal sites.

**Methods**

Modeling and on-site measurements are integrated to assess the microclimate conditions of different UGS and underlying driving factors, including local background climate, urban spatial characteristics, and vegetation. As a new generation of UCMs, the Urban Tethys-Chloris (UT&C) model is used for this study, which is a novel urban ecohydrological model with an explicit representation of urban canyon and vegetation (Meili *et al.*, 2020, 2021). First, 15 models for each UGS are set up in UT&C for microclimate simulation. The model inputs include meteorological forcing, urban geometry, and vegetation properties. Meteorological forcing data will be obtained from MeteoSwiss, which provides hourly observations at the station level. Urban geometry such as average canyon width, building width, and height are estimated from elevation models from Swisstopo (Swiss Federal Office of Topography swisstopo, 2021, 2023). Land cover fractions are extracted from habitat maps of Switzerland (Bronwyn Price *et al.*, 2021). Second, the model results will be validated against on-site measurements. We will use sensitivity analysis to identify a set of the most influential vegetation parameters and optimize them to minimize the gap between measurement data and simulation results. In each UGS, we have selected a sunny and a shaded spot to install sensors and observed the data for summer from July to October 2023, including air temperature (T) and relative humidity (RH) at 2-meter height, volumetric water content (VWC) at 25-centimeter depth, and surface temperature (ST). Due to budget constraints, sensors for wind speed (WS), shortwave (S↓) and longwave (L↓) radiation were only installed in ruderal sites in each city. The model output consists of average hourly data on T, RH, VWC, etc. Model performance will be accessed by calculating the coefficient of determination, root mean square error, mean absolute error and mean bias error of measured and simulated T, ST, and VWC for each UGS. Last, statistical regression will be applied to get the relationship between parameters of vegetation, urban fabric, background climate, and simulation results across the 15 UGS.

## Results and analysis

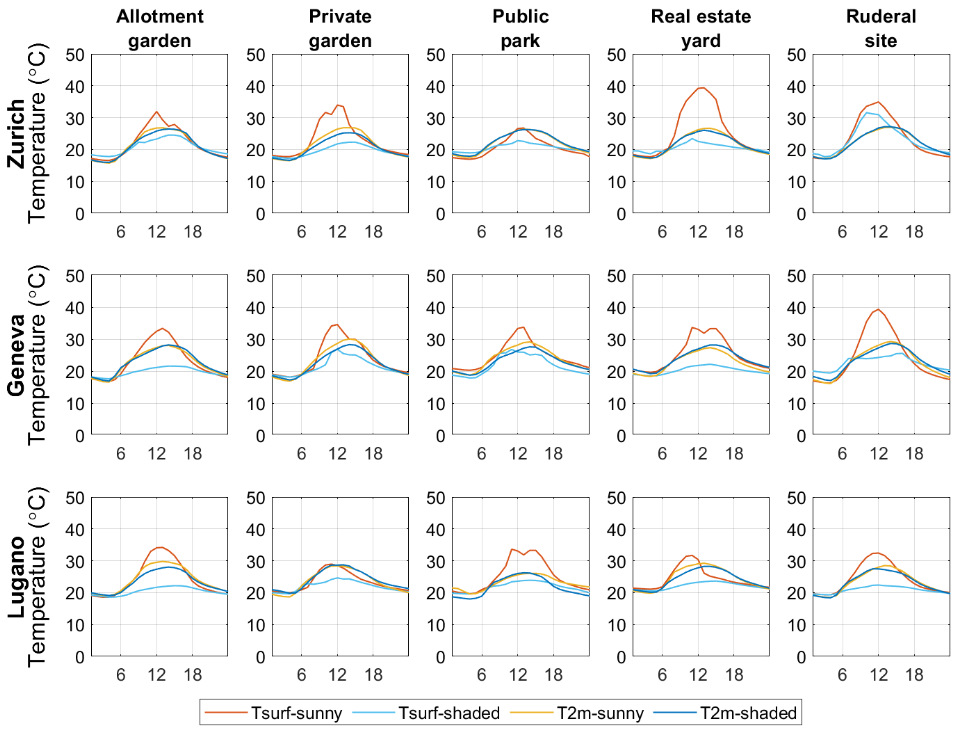


Fig.2 shows the average diurnal cycle of measured 2-meter air temperature T2m and surface temperature Tsurf in sunny and shaded spots for each UGS, with each row representing the same city and each column representing the same type of UGS. Air temperatures were observed highest in Zurich's private garden (29 ºC) and lowest in Geneva's ruderal Site (26 ºC) during the hottest hour of the day across the 15 UGS. Within the same city, air temperatures vary by an average of 1.0 - 2.8 C ºC and surface temperature varies by 1.0-2.2 ºC in peak hour. For a single UGS, it is observed surface temperature in sunny and shaded spots shows extremely higher and lower values compared with air temperature, which means surface temperature is more affected by sunlight than air temperature. Specifically, the temperature difference is 2.7 ºC between sunny and shaded sensors for surface temperature and 0.2 ºC for air temperature.

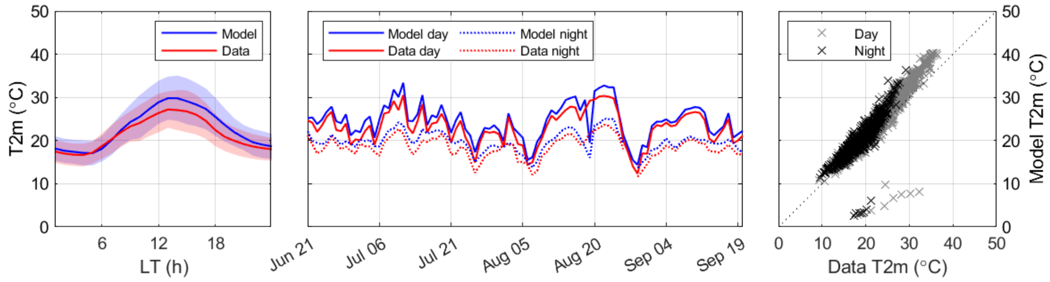


Fig.3 compares the modeled and simulated 2-meter air temperature of the private garden in Zurich. The results show good agreement with R-square being 0.87 and RMSE being 2.61 ºC. However, it is also noticed that UT&C overestimated the air temperature than measurement data, especially during daytime. Similar performance assessments are also conducted for other UGS concerning their surface temperature and volumetric water content. The model performance is better for air temperature and surface temperature with an average R-square higher than 0.80, while R-square is around 0.54 for VWC. Further analysis will include sensitivity analysis for each site, vegetation parameter optimization, and regression analysis on the impact of the most influential factors on microclimate conditions.

**Reference**

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