MODELING OF STREET TREES FOR URBAN MICRO-CLIMATOLOGY IN STRASBOURG – THE TIR4STREET PROJECT

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Modélisation des arbres urbains pour la climatologie urbaine à Strasbourg – Le projet TIR4sTREEt

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Introduction

Urban vegetation acts as a microclimate regulator through transpiration and by providing shade for pedestrians and facades, thereby reducing surface temperatures of buildings and ground. The intensity of this phenomenon depends on the characteristics of the tree (species, leaf density, size, crown geometry, proximity to buildings, isolated or park trees), the soil and the surrounding environment. Street trees can have a significant impact on air and surface cooling, with a potential decrease of 2°C to 3°C and more than 10°C respectively (Gillner *et al.,* 2015). The project TIR4sTREEt (*Thermal Infrared for Street Trees*) aims to enhance our understanding and quantify the effect of three different species of street trees on urban climate, with a particular focus on surface temperature. To achieve this, the project's first objective is to conduct full-scale measurement campaigns of both seasonal street microclimate (soil, air, buildings) and tree functioning. The second objective is to develop a methodology for merging the geometry of an urban scene with the measured surface temperatures. The thermal 3D model can be used, in a third objective, to validate estimates produced by microclimatic simulation tools, currently being developed by the consortium, namely the LASER/F model (*LAtent SEnsible Radiation Fluxes*) adapted to the scale of a district (Kastendeuch *et al.,* 2017) and the RATP model (*Radiation Absorption, Transpiration and Photosynthesis*), operating at the scale of an individual tree (Sinoquet *et al.,* 2001). By coupling both, it is possible to analyse and model the impact of trees and urban morphology on the urban climate. In the long term, these findings will help urban planners to propose greening scenarios and thus improve the ambient climate.

Measurement campaign and first results

Simulating the energy balance at the scale of a street remains a major challenge, even if the processes are known. This is because it requires faithful reproduction of the geometry and physical characteristics of the surface, as well as all the energy exchange processes that take place between these elements. A large measurement campaign was conducted in the summer of 2023 to collect micro-climatological, meteorological, 3D, thermal, and eco-physiological information on several trees. The study area encompasses three adjacent streets in Strasbourg lined with alignment trees of three different species (lime, hackberry and plane trees).

In collaboration with Eurométropole et Ville de Strasbourg (EMS), meteorological and thermal sensors have been installed on masts. Evapotranspiration (ETR) plays a crucial role in regulating ambient air temperature. Therefore, sap-flux sensors, wireless dendrometers, and soil moisture sensors were placed on and near selected trees. The 3D model of the street was reconstructed mainly from terrestrial laser scanning data with two levels of detail.

Thermal infrared images have been acquired using four cameras of different specifications, from both static and mobile viewpoints (Lecomte *et al.,* 2024a) (Fig. 1). A trolley system has been specially designed to carry out mobile measurements along horizontal transects during heatwave days, moving along roads at three key times of the day (sunrise, sun culmination, sunset). It is equipped with low-cost Red, Green, Blue cameras and a thermal infrared (TIR) camera. In the near future, a mobile system based on an aerial manipulator robot attached to a tethered balloon will be used to capture TIR measurements dynamically along a vertical transect.

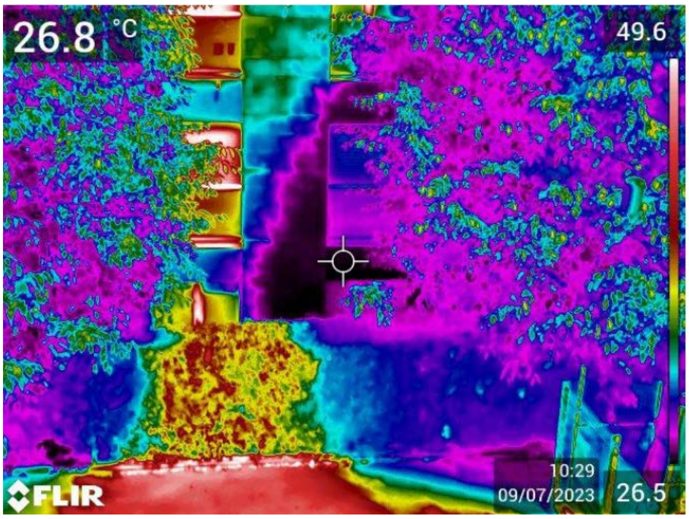

Figure 1. Thermal infrared image of a façade, acquired with a TIR camera (FLIR T560) on the 9th of July, 2023.

Work in progress

The collected measurements are currently under analysis. First experiments were conducted to generate thermal point clouds by merging the 3D model with measured surface temperatures. They have shown promising results, even for trees (Lecomte *et al.,* 2022). A methodology is being developed to create a temporal 3D thermal model on the whole scene based on the measurements performed during the campaign. The resulting model will be compared to surface temperature and shading simulations (Lecomte *et al.,* 2024b). This step is of great interest for refining urban microclimatic models. Indeed, it is a challenge to accurately reproduce the physical effects of buildings and trees on ETR, surface temperature, and thermal comfort.

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