

Temperature mitigation by urban trees: Modelling the cooling effect of transpiration and shading on a single tree basis

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TEMPERATURE MITIGATION

$$TM = Ev + S$$

Ev = Evapotranspiration (cooling effect)

S = Shading (LAI)

$$EV = VPD * (Rs + Ra)^{-1} * LAI^{-1}$$

VPD = vapor pressure deficit

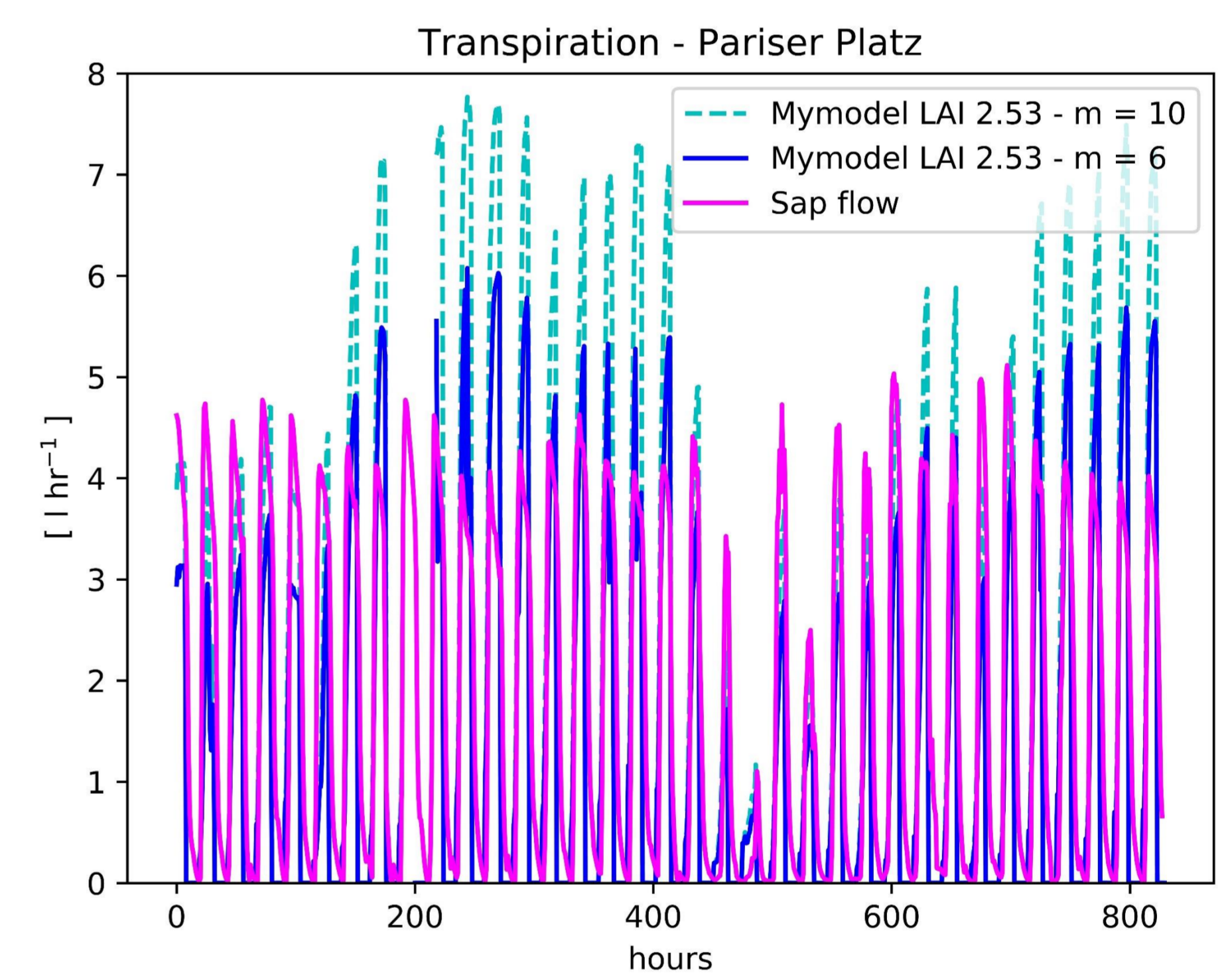
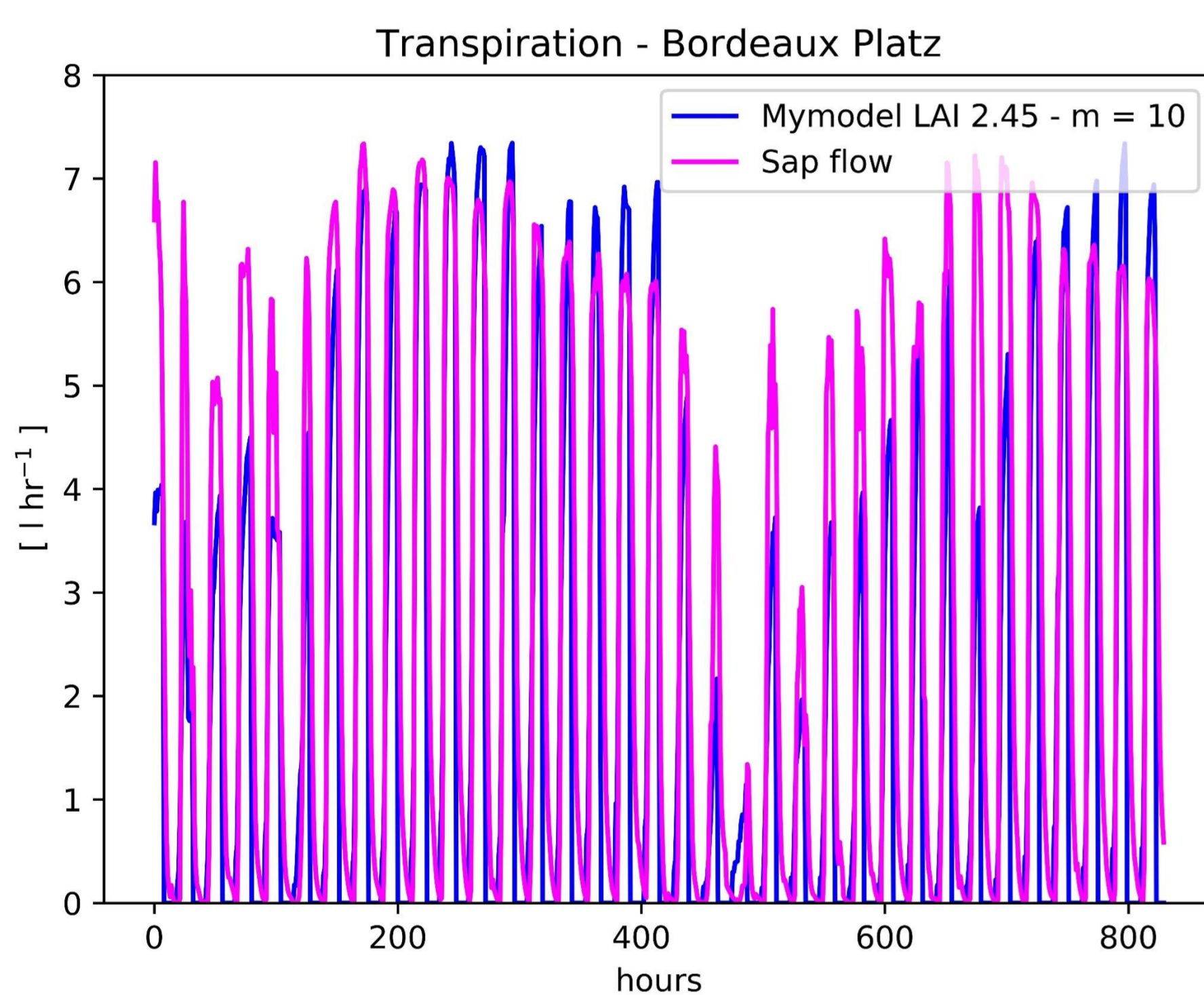
Rs = stomatal resistance

Ra = aerodynamic resistance



COOLING VALIDATION

- Munich – *Tilia cordata* (5 trees x site)
- Time: July 28th – August 31st 2015
- Bordeaux Platz = open green square (+ wind speed; - drought)
- Pariser Platz = circular paved square (- wind speed; + drought)



SHADING CALCULATION

$$\Delta T = 2.38 + 4.63 \times LAD$$

$$LAD = LA \times Vc^{-1}$$

$$L \uparrow = \varepsilon \times \sigma \times T^4$$

$$\Delta Q = Q \downarrow \times e^{-k \times LAI}$$

T = surface temperature (K)

LAD = leaf area density (m² m⁻³)

LA = leaf area (m²)

Vc = crown volume (m³)

L ↑ = thermal radiation (W m⁻²)

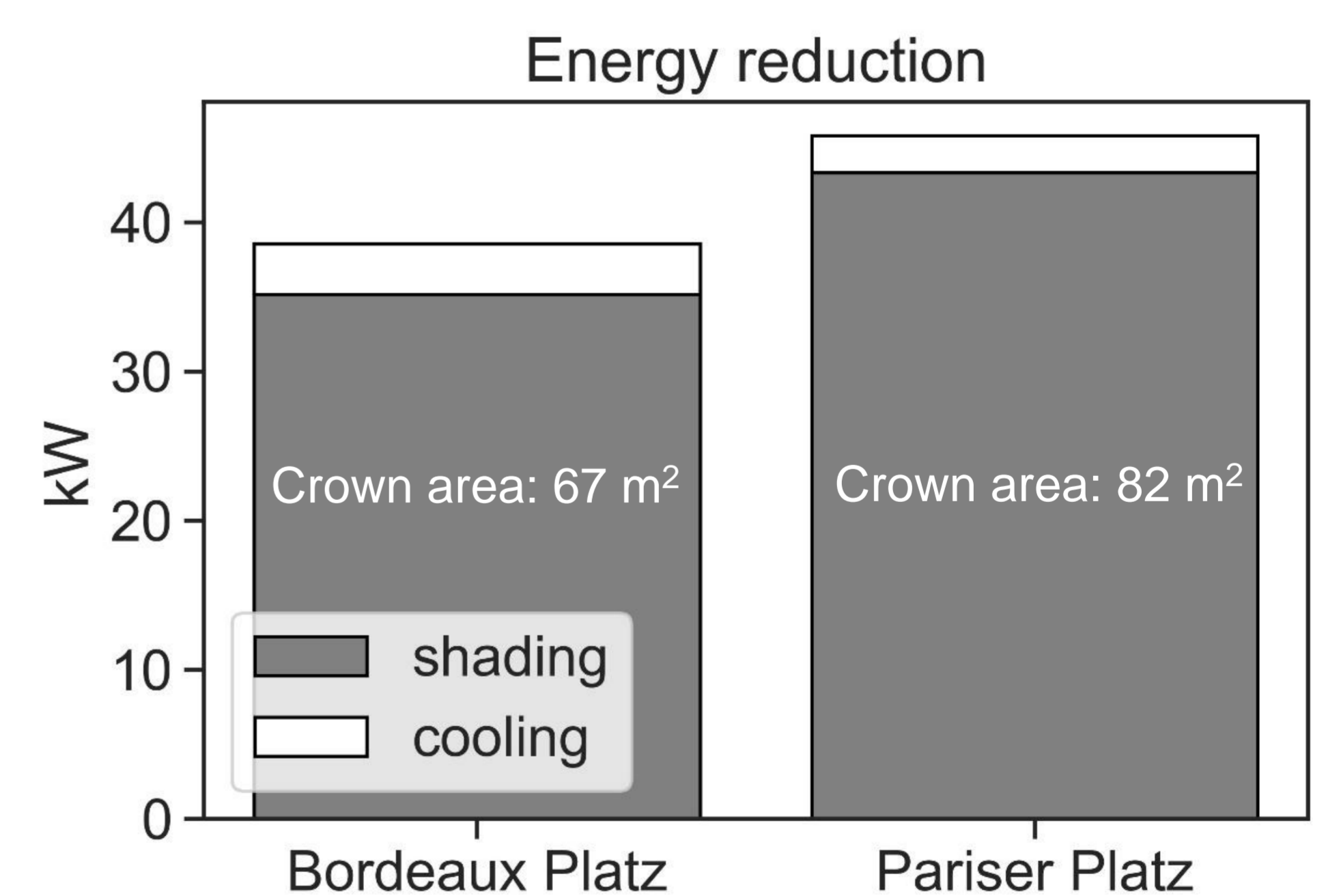
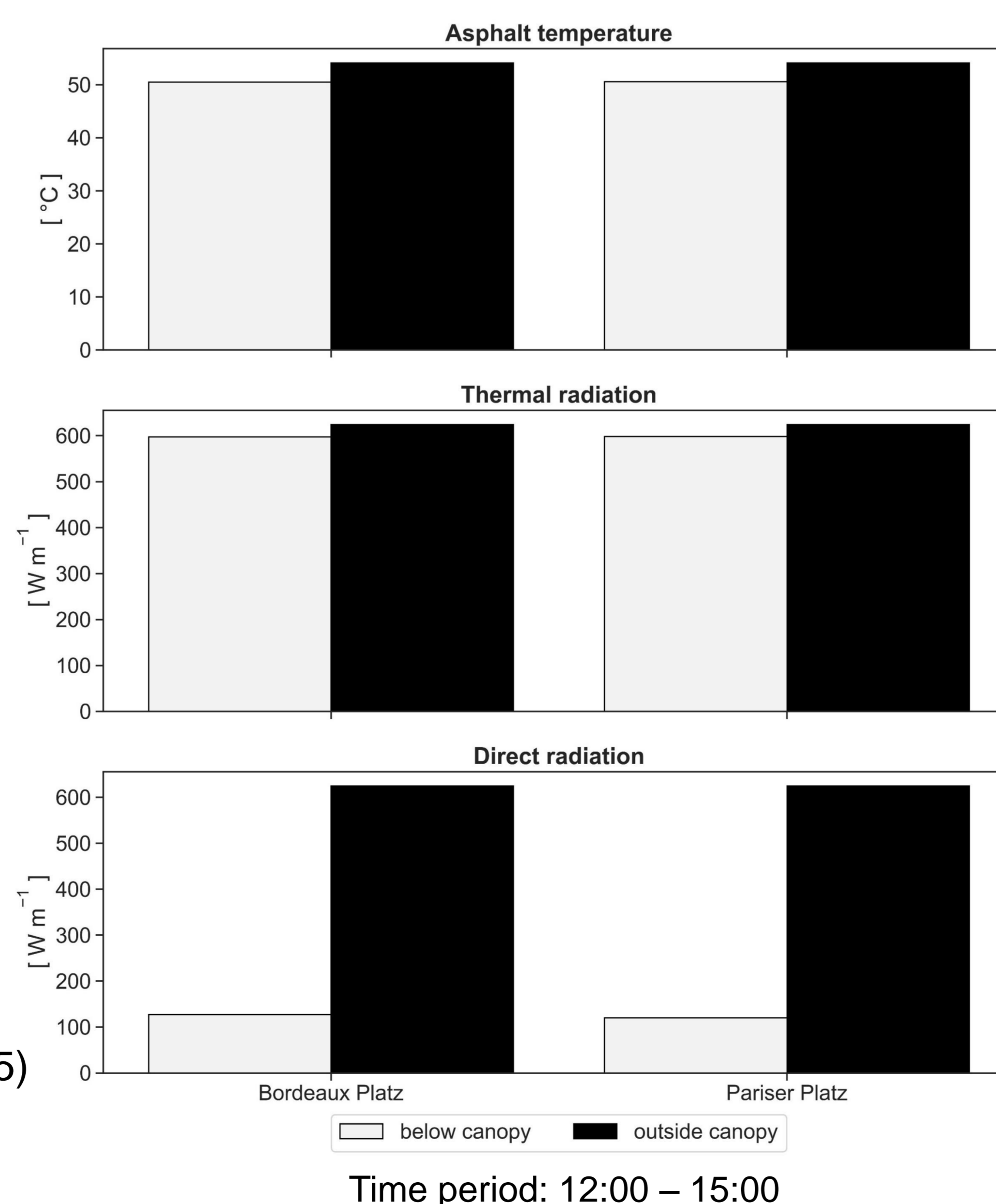
ε = Stefan-Boltzmann-Constant

σ = emissivity (asphalt: 0.96)

Q ↓ = direct solar radiation (W m⁻²)

k = extinction coefficient (hardwoods: 0.65)

LAI = leaf area index (m² m⁻²)



MAIN CONSIDERATIONS

- Microclimate (e.g. wind speed) and soil water availability affects the transpiration;
- Shading is related to the crown dimension;
- Energy reduction depends on shading (++) and cooling (+)

References

Rahman et al. 2017 - Microclimatic differences and their influence on transpirational cooling of *Tilia cordata* in two contrasting street canyons in Munich, Germany.
Scholz et al. 2018 - Cooling effects and regulating ecosystem services provided by urban trees-Novels analysis approaches using urban tree cadastre data.

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