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STREET TREE ECOHYDROLOGY

A project to study street tree water use strategies and their consequences for managing tree cooling effects



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Introduction

- Lifespan of urban tree is reduced compared to trees in natural areas¹. Many uncertainties remain concerning the factors that affect tree mortality².
- Water availability is an essential factor for tree survival, growth and for tree ability to mitigate urban heat islands (UHI) through evapotranspiration³.
- In urban area, impervious surfaces reduce precipitation infiltration in soils and increase water stress for trees⁴.
- Several studies support the influence of water stress on tree vitality and its consequences on ecosystem services, but more data is needed^{3,4}.
- To further investigate these issues we developed a three year pluridisciplinary project on street trees of Paris, France.

Questions

- 1 Do we observe water stress in street trees?
- 2 Does this influence tree vitality and functioning, and how?
- 3 How street trees contribute to UHI mitigation?

Material

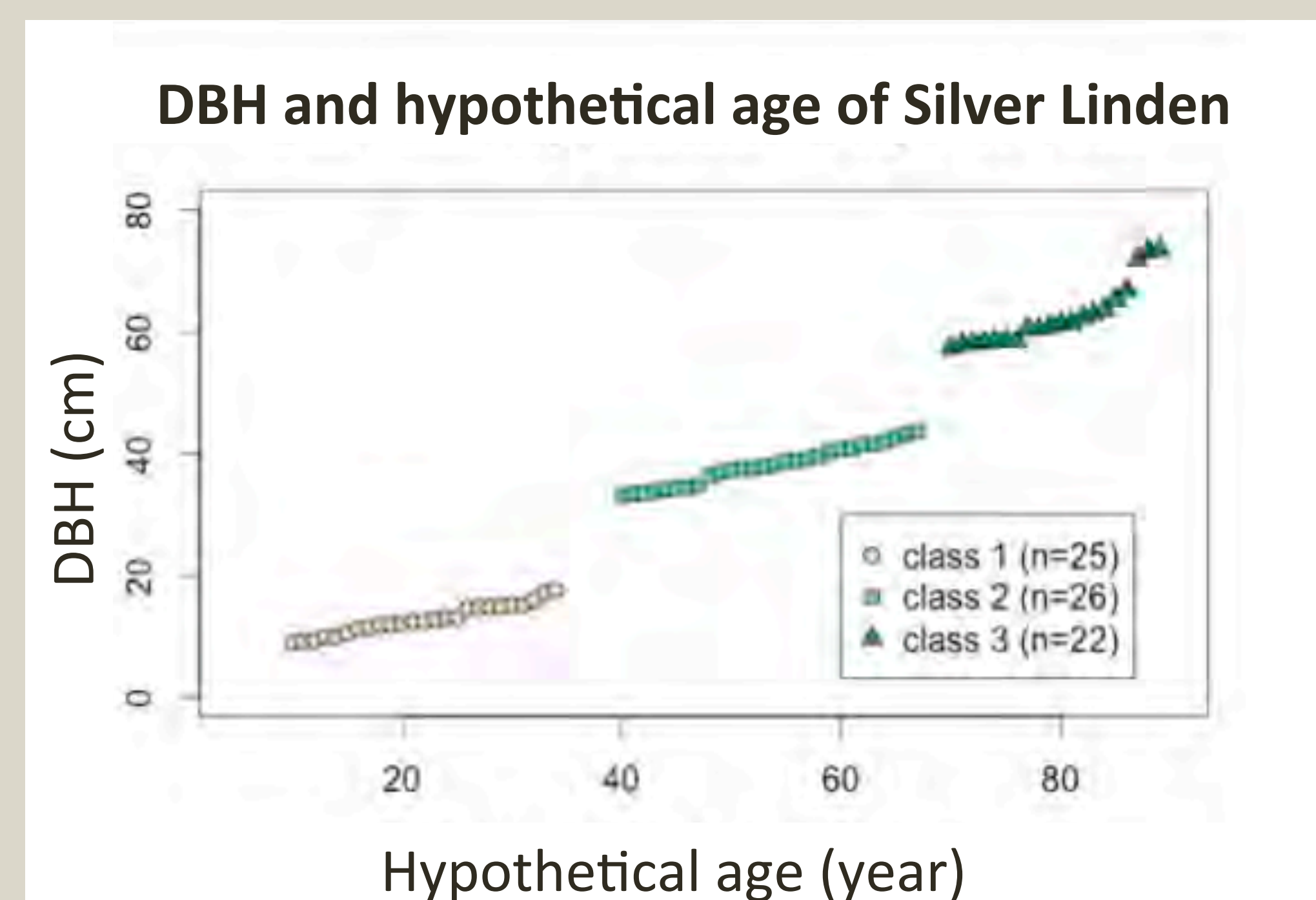
Chronosequence of 80 street silver lindens in Paris



Tilia tomentosa
Moench, Silver Linden⁵



Tree core sampling in Paris (March 2014)



Class 1 DBH: [6,8 ; 14,6] cm
Class 2 DBH: [32,5 ; 42,7] cm
Class 3 DBH: [56,6 ; 73,2] cm

Framework and expected results

WP1. Hydric functioning of silver linden

Relationship between *T. tomentosa* and its local microenvironment through its extern and intern morphology

Macroscopic study

- Health status using DEPEFEU and reserve quantity in roots
- Biometrical characteristics: Height, Diameter at Breast Height, Leaf Area Index
- Microclimatic parameters: luminosity, temperature, humidity, precipitations



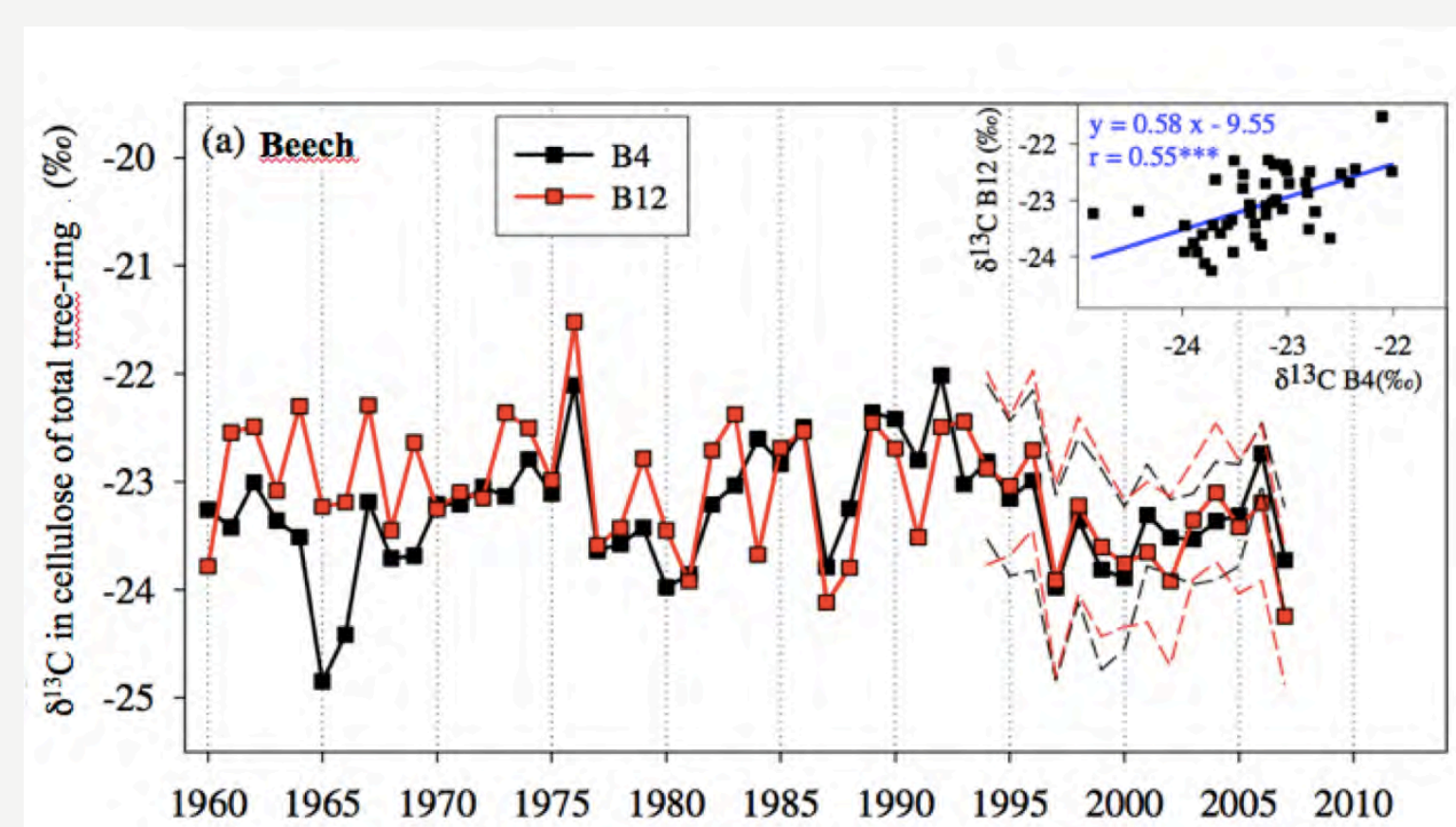
Tree core extraction with Pressler borer (March 2014)

Microscopic study of silver linden wood

- Number of tree-rings: age estimation
- Tree-ring width: retrospective relation between growth and climate
- Xylem characteristics: water storage capacity, water transport efficiency, hydraulic conductance and embolism vulnerability
- Water stress: hydric potential, abscisic acid and proline content in leaves

Isotopic study

- $\delta^{13}\text{C}$ composition of tree-rings a retrospective study of the water stress and Water-Use Efficiency (WUE) of tree
- $\delta^{13}\text{C}$ composition of leaves as an instantaneous study of the water stress and Water-Use Efficiency (WUE) of tree



Inter-annual variations of cellulose $\delta^{13}\text{C}$ from 1961 to 2007 in beech⁶

REFERENCES

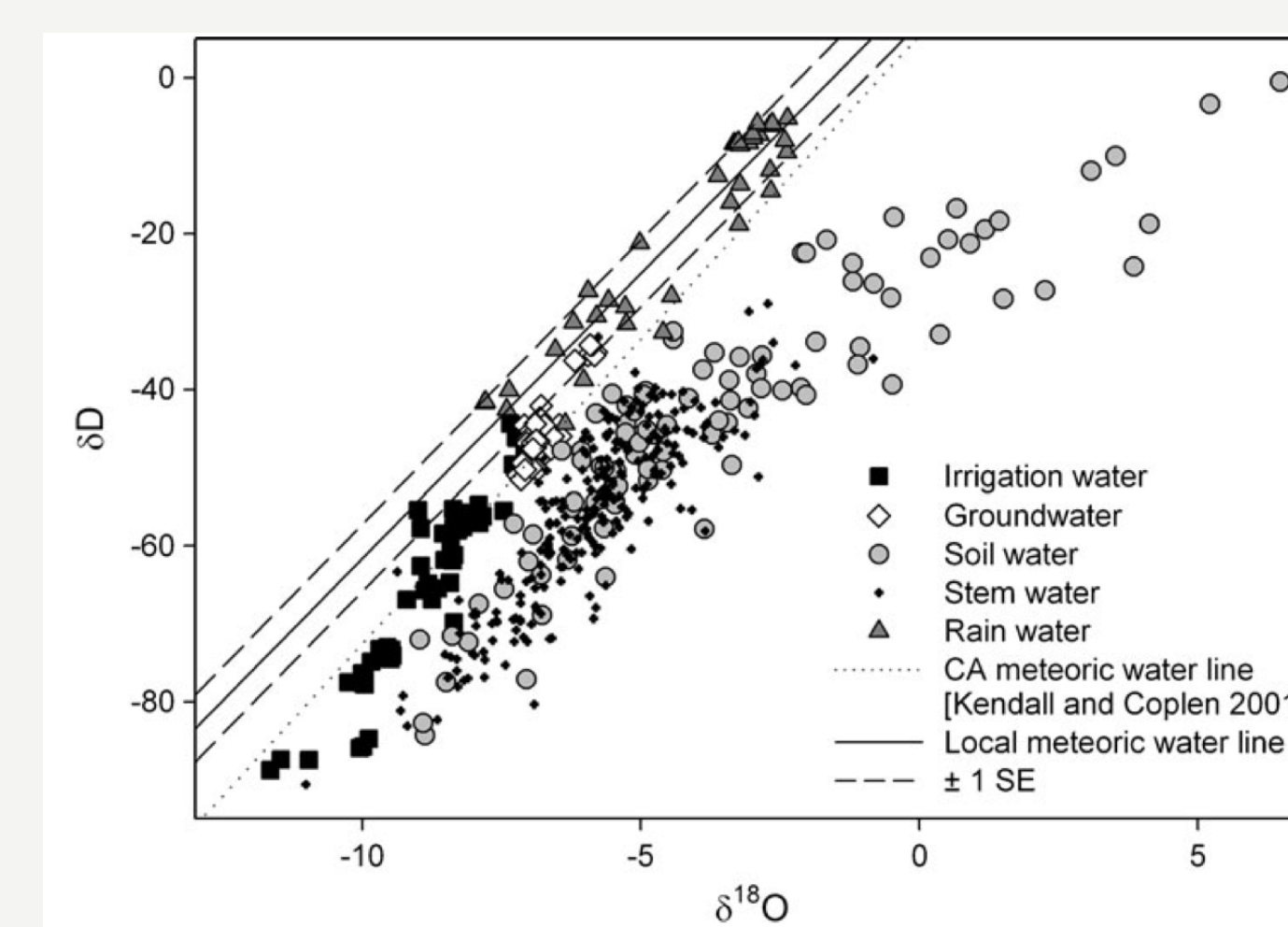
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- ⁴Whitlow & al (1992) A 3-year study of water relations of urban street trees. *Journal of applied ecology* 29: 436-450
- ⁵forestryimages.org
- ⁶Michelot (2012) Croissance et $\delta^{13}\text{C}$ des cernes de trois essences forestières tempérées face aux variations climatiques à l'échelle interannuelle et saisonnière. PhD Thesis. U-PSud
- ⁷Bijoor & al (2012) Water sources of urban trees in the Los Angeles metropolitan area. *Urban Ecosystems* 15:195-214
- ⁸Leuzinger & al (2010) Tree surface temperature in an urban environment. *Agricultural and forest meteorology* 150:56-62

WP2. Water-use strategies of silver linden

Localization of water sources and evapotranspiration of urban trees

Seasonal and spatial variations of water sources

- Characterization of oxygen and hydrogen isotope profiles in xylem water and several water sources
- Isotope profiles of $\delta^{18}\text{O}$ and soil water content (SWC) in soil cores



The isotopic composition ($\delta^{18}\text{O}$ and δD) of all irrigation, groundwater, soil water, stem water, and rainwater samples⁷

Water-use of street *T. tomentosa*

- Seasonal and annual water consumption and evapotranspiration using sap flux
- Monitoring the seasonal modulation of photosynthetic activity by measuring chlorophyll fluorescence of leaves

WP3. Silver linden and cooling effect

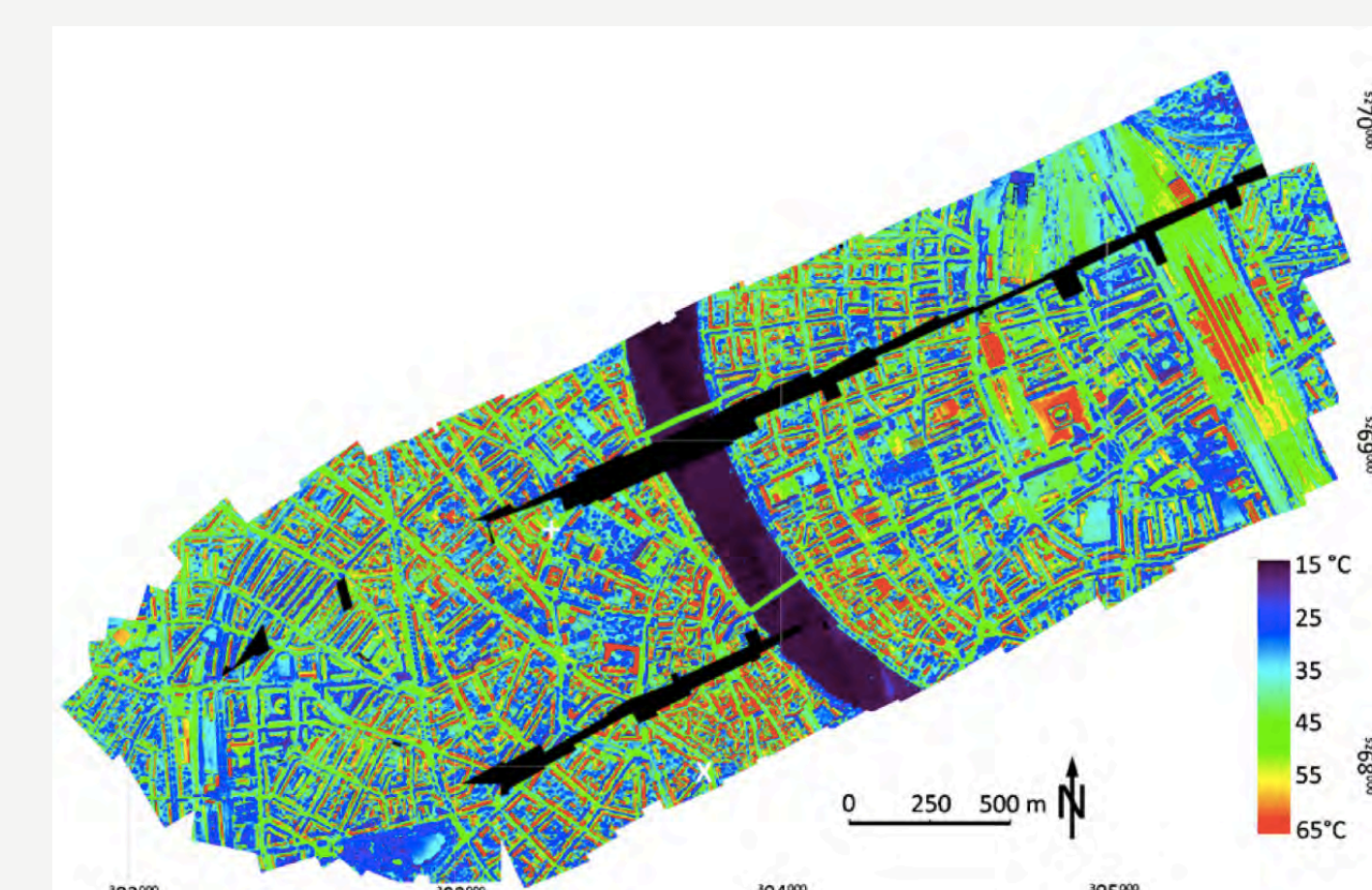
Contribution of street trees to urban heat island mitigation and guidelines for a sustainable management of urban trees in Paris

In-situ irrigation experiment

- Street tree responses under several irrigation treatments

Cooling effect of street trees

- Comparison of microclimatic conditions between streets with and without trees
- Monitoring phenology and UHI by Normalized Difference Vegetation Index (NDVI) using MODIS Satellite data
- Including the impact of trees in a model of energy balance in a street



Picture with false colours, legend showing corresponding temperatures on the right⁸