HYPERCITY

Air quality biomonitoring in cities: a hyperspectral approach

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KNOWLEDGE IN ACTION

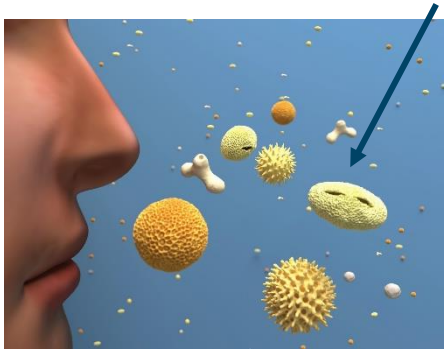
VNIVERSITAT DE VALÈNCIA

Belgian Science Policy Office
belspo

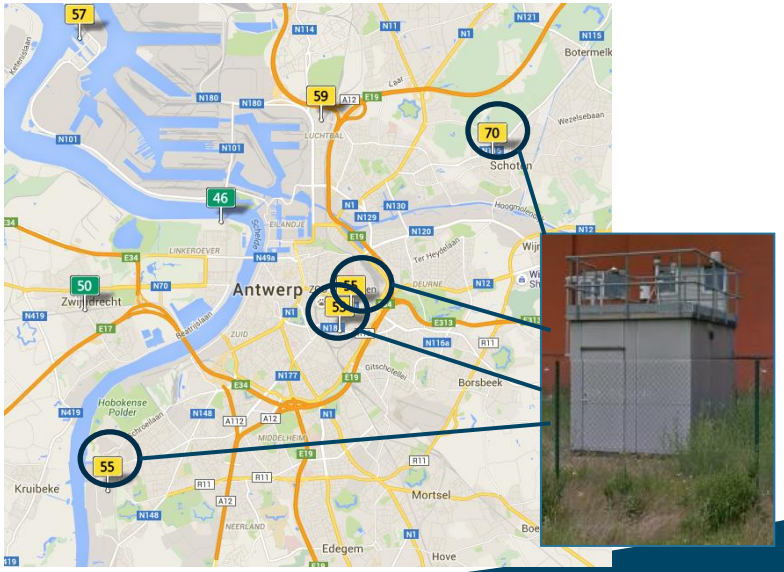
Belgian Earth Observation day 2016

Risk of air pollution

Particulate matter (PM)



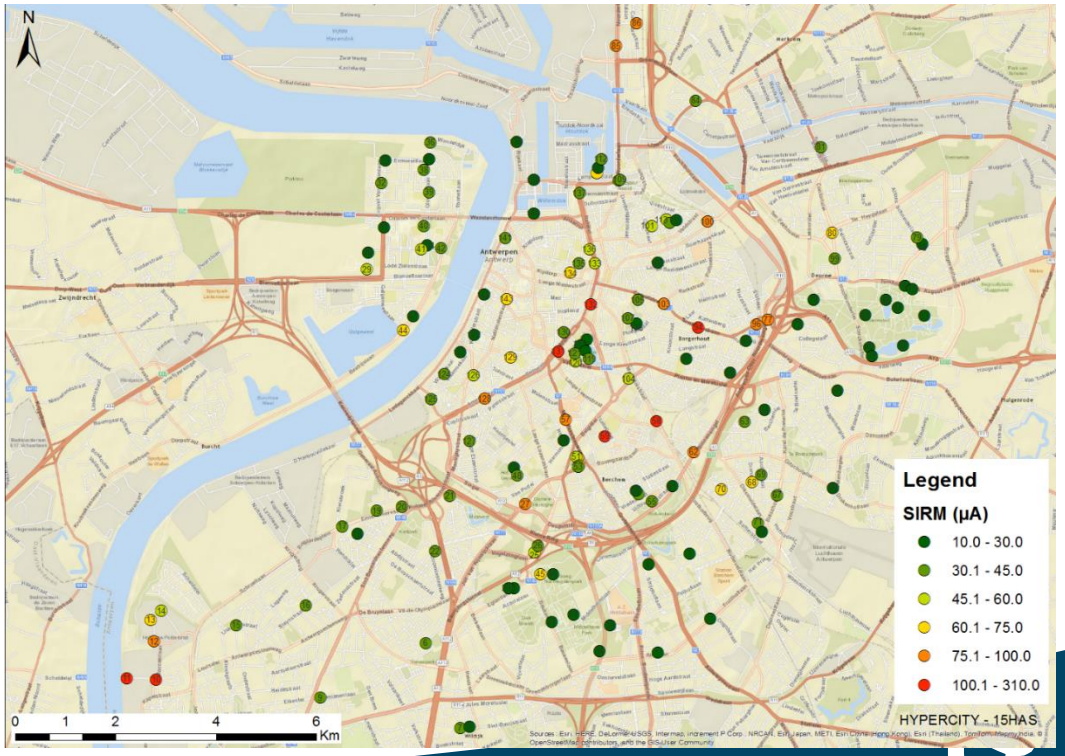
Air pollution monitoring stations: coarse-scale information



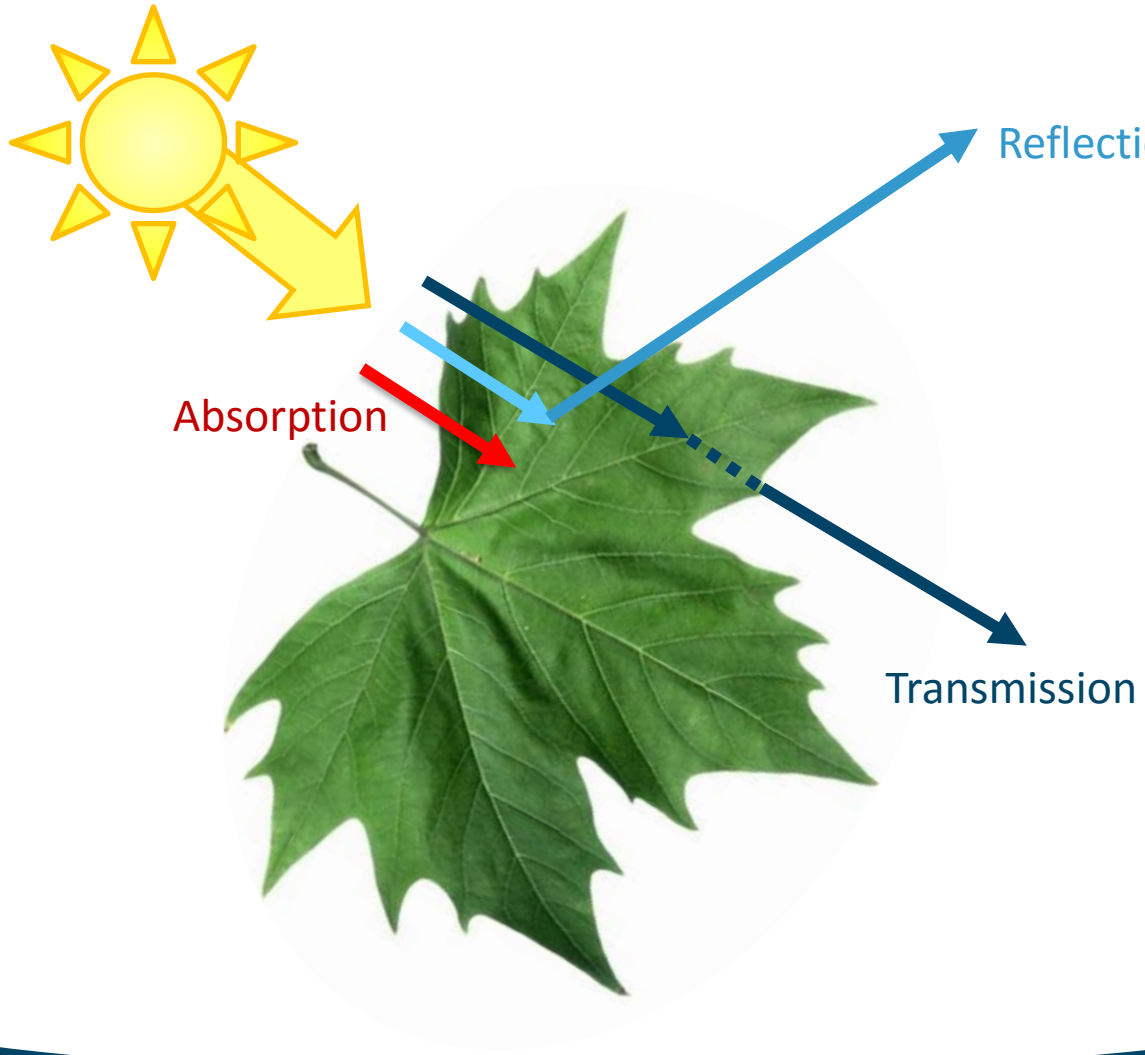
Risk of air pollution

Get insight in spatial distribution of air pollution on **high spatial resolution**

Biomonitoring of local urban green



Light – leaf interaction

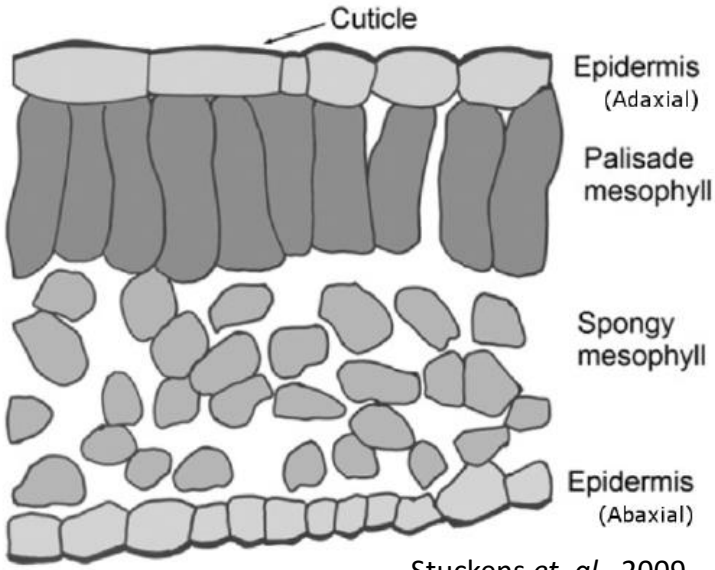


CHARACTERISTICS
- Leaf surface
- Internal structure
- Leaf thickness
- Water content
- Biochemical composition
- Pigment concentration

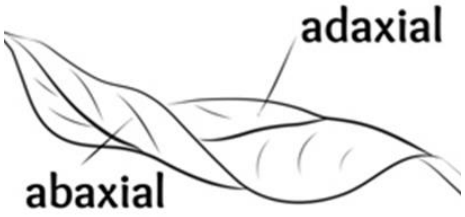
Pollution

HYPERCITY project

- Potential of **hyperspectral** leaf reflectance and chlorophyll **fluorescence** as an indicator for urban air quality.
- Both at **leaf** and **canopy** level
- Dorsi-ventral leaf **asymmetry** taken into account



Stuckens *et. al.,* 2009

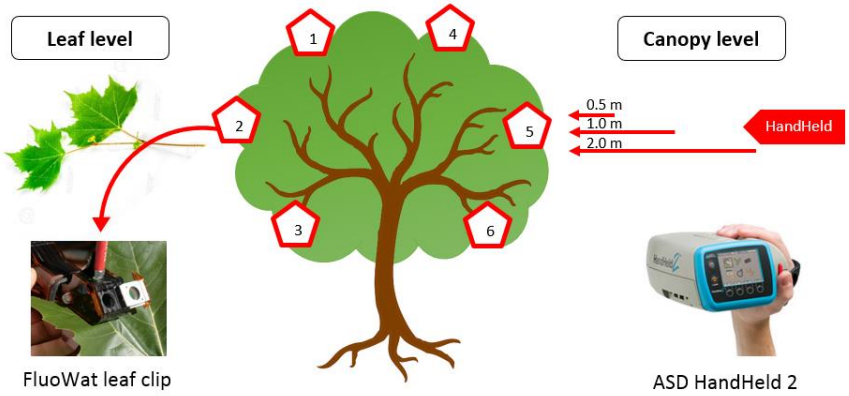


HYPERCITY project: dual approach

MAPPING

- Physiological and reflectance based leaf characteristics
- Trees spatially distributed over the entire urban area
- Urban classes: park, street and industry/harbour

UPSCALING



- Large solitary trees growing in various contrasting urban environments in terms of air pollution
- Upscaling from leaf level to tree level
- Vertical gradient and at two wind directions

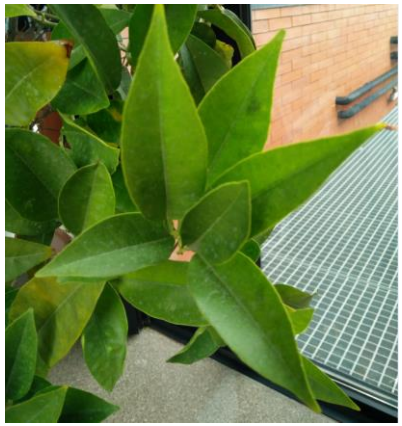
Field campaigns

2015 Antwerp

- London plane tree (*Planatus x. acerifolia*)

2016 Valencia

- London plane tree (*Planatus x. acerifolia*)
- Orange tree (*Citrus aurantium*)



2017 Antwerp and Valencia: airborne campaign

- Intensive upscaling campaign

Field campaign 2015: Antwerp

Tree campaign organised:

- **Antwerp SIRM campaign**
  - Saturation Isothermal Remanent Magnetization (SIRM), a magnetic leaf biomonitoring approach
  - Mapping **spatial variation** in urban air quality as necessary background data
  - Interpret the measured physiological and reflectance data in function of urban air quality
  - 143 trees

- **Antwerp Mapping campaign**
  - Map urban air pollution using physiological and reflectance based leaf characteristics
  - 44 trees

- **Antwerp Upscaling campaign**
  - **Scale up** hyperspectral leaf reflectance data to canopy level
  - 2 trees, measurements at six locations in crown

Field campaign 2016: Valencia

Four campaign organised, two at Plane tree and two at Orange tree:

- **Valencia Mapping campaign**
  - Map urban air pollution based on physiological and reflectance based leaf characteristics
  - 12 plane trees analysed in July

- **Valencia Upscaling campaign**
  - To see intra-canopy variation: measurements at different heights and at different wind directions (only leaf level)
  - 2 plane trees analysed at the end of July

- **Orange tree May/August/October campaign**
  - Investigate the temporal differences of pollution on the leaves
  - 4 orange trees, 2 at park area and 2 at high traffic street, analysed in May, August and October

- **Orange tree-upscaling campaign**
  - Scale up hyperspectral leaf reflectance data to canopy level
  - 2 orange trees measured at nadir, at different heights, analysed in July

Measurements

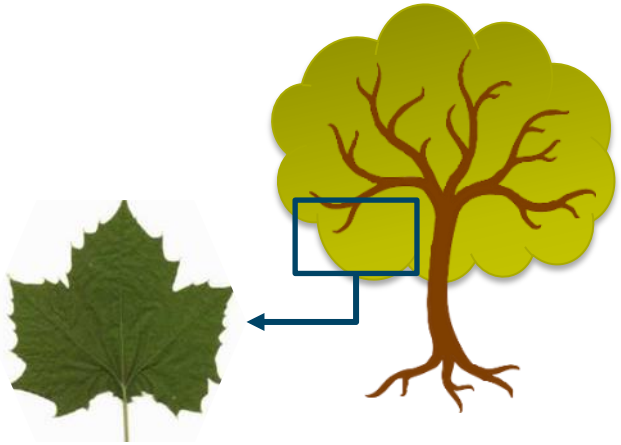
Sampling:

Fully developed and intact leaves at branches

At the lower canopy (height 3.0 – 5.5 meters)

Analysis on **leaves**:

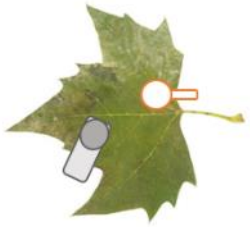
1. Chlorophyll fluorescence with plant efficiency analyzer (**PEA**; Hansatech Walz, England)
2. Hyperspectral reflectance/transmittance measurements and sun-induced fluorescence with **FluoWat** leaf clip coupled with ASD spectroradiometer (350 nm – 2500 nm)
3. Fluorescence imaging with Fluorescence Imaging System (**FIS**)
4. Leaf characteristics:
   - Leaf water content (LWC)
   - Specific leaf area (SLA)
   - Relative chlorophyll content (RCC)
   - Nitrogen content (NC)
   - Leaf cross sections
5. **SIRM** measurements



Measurements

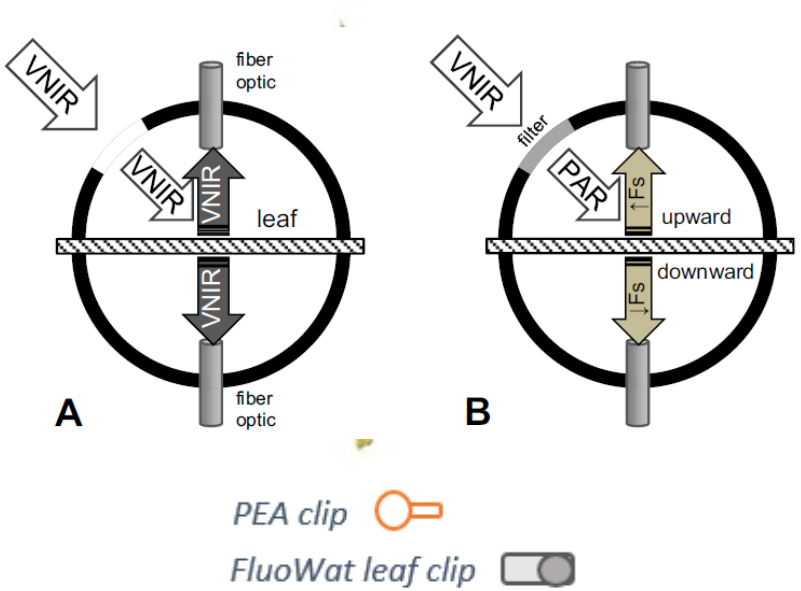
1. Chlorophyll fluorescence with **plant efficiency analyzer** (PEA)

- On adaxial and abaxial leaf side
- Measures fast fluorescence induction in dark adapted leaf after saturation light pulse.



Measurements

2. Hyperspectral reflectance/transmittance measurements and sun-induced fluorescence with **FluoWat** leaf clip coupled with ASD AgriSpec/Fieldspec

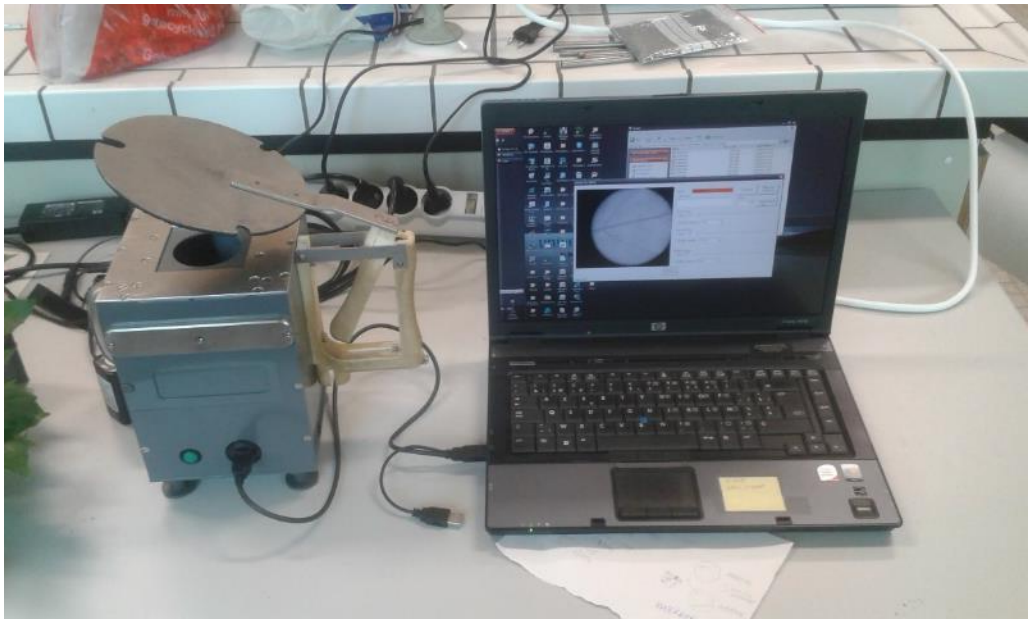


- Measurements on adaxial leaf side in Antwerp, on both leaf sides in Valencia.
- Both **reflectance**: fiber optic attached to the upside, and **transmittance**: fiber optic attached to the downside of the FluoWat leaf clip.
- Filter allows measurement of true **fluorescence**.

Measurements

3. Fluorescence imaging with Fluorescence Imaging System (FIS)

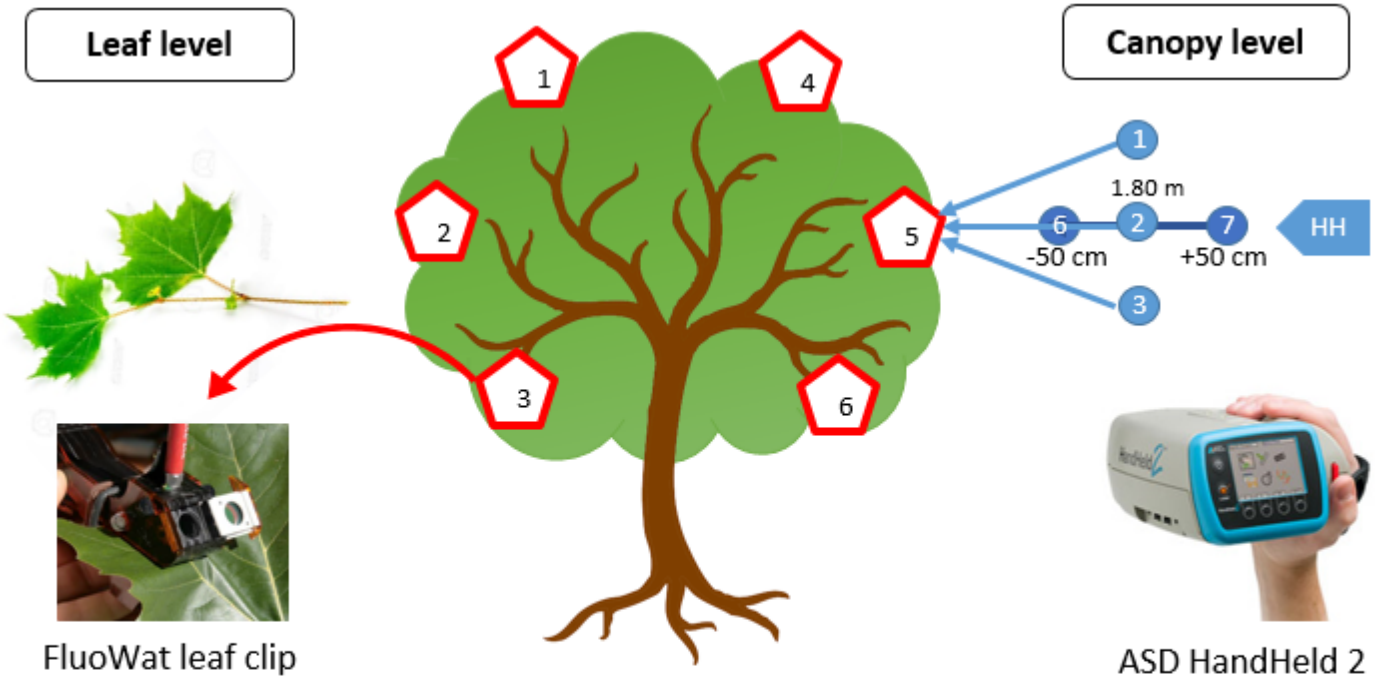
- Measurements on both adaxial and abaxial leaf side.
- Larger surface of the leaf is measured.



Upscaling campaign Antwerp

For two **plane** trees

1. At contrasting areas: with high air pollution level and in an area with urban background pollution level
2. On **two** levels: leaf level and canopy level (remote sensing)



Upscaling campaign Valencia

For two **plane** trees

1. At contrasting areas: with high air pollution level and in an area with urban background pollution level
2. On **one** levels: leaf level at different positions in the canopy

For two **orange** trees:

1. At contrasting areas: with high air pollution level and in an area with urban background pollution level
2. On **two** levels: leaf level (at different positions) and canopy level (remote sensing) → nadir measurements

Orange tree: temporal variation

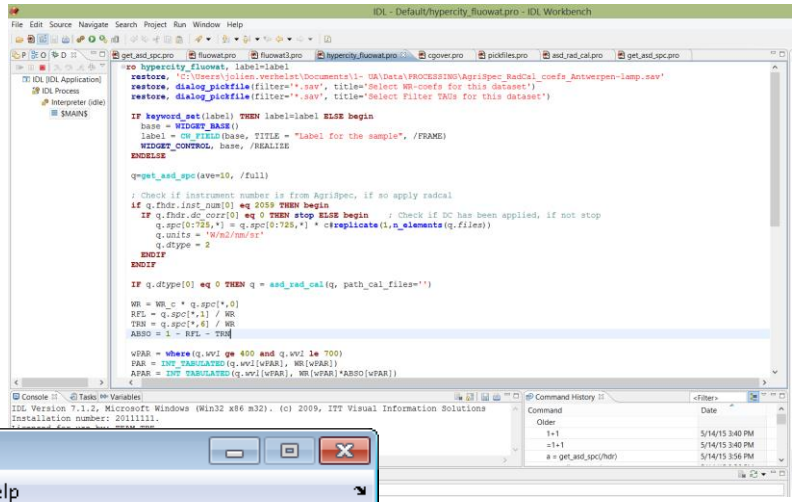
Repetition of measurements in May August and October

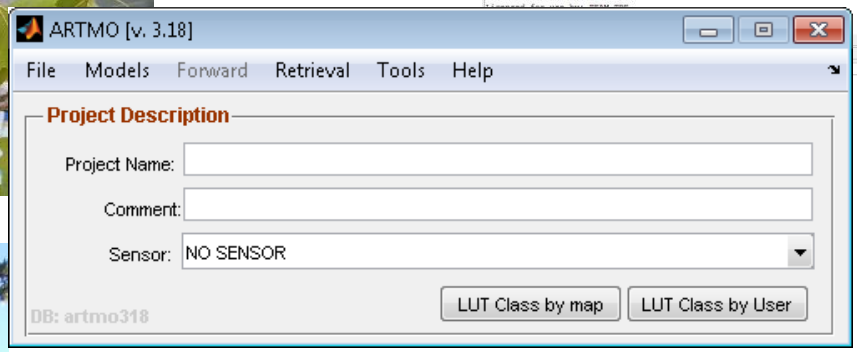
- *Citrus aurantium*
- Different age cohorts: new leaves appear along autumn, winter and spring

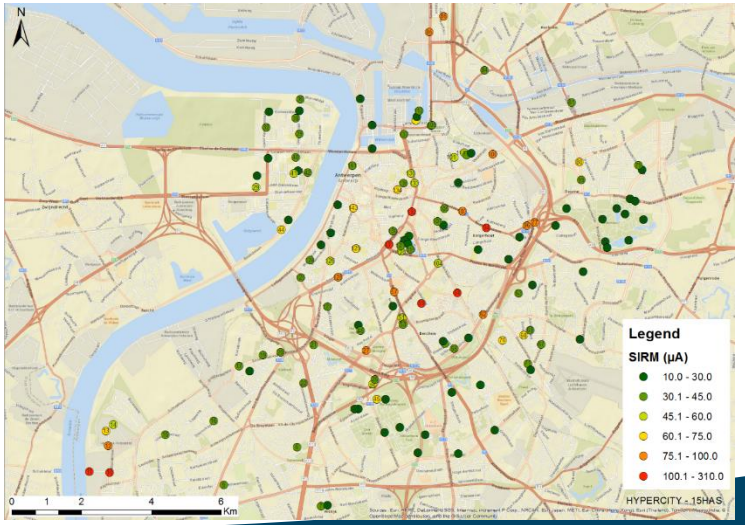
Measurements:

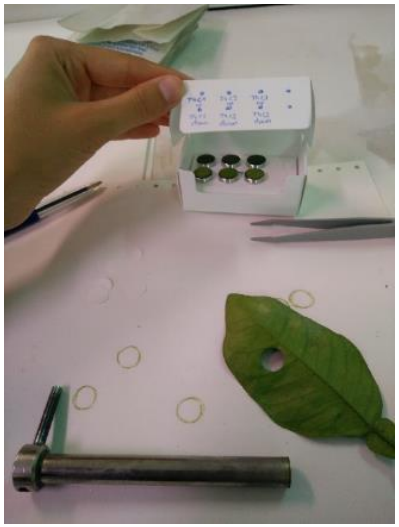
- 2 trees x 2 locations: location (1) high traffic road – location (2) park area
- Same light conditions
- Three cohorts are sampled: C1, C2 and C3

Data processing









HYPERCITY website

ENdEMIC
Environmental Ecology and Applied Microbiology
University of Antwerp

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https://www.uantwerpen.be/en/projects/hypercity/

The HYPERCITY project

HYPERCITY stands for "HYPERspectral biomonitoring: air quality and the CITY"

In this study the potential of hyperspectral reflectance and chlorophyll fluorescence as an indicator for air quality is explored, both at leaf and at canopy level.

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About HYPERCITY
- Objectives
- Partners

Field campaigns
- Antwerp 2015
- Valencia 2016