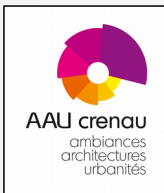


# Urban heat island and inertial effects : analyse from field data to spatial analysis



Jérémy BERNARD<sup>(1)</sup>,  
Marjorie Musy, Isabelle Calmet,  
Erwan Bocher, Pascal Kéravec

(1) IRSTV / CRENAU

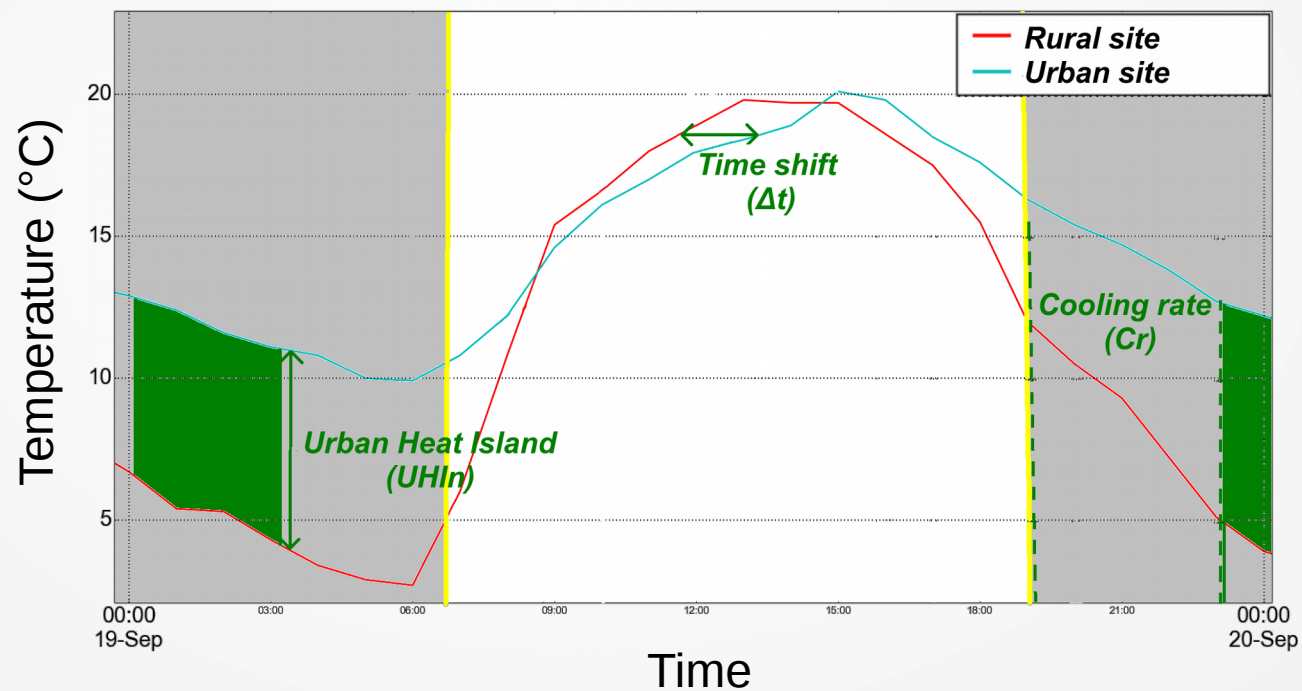


# Context

Observation : behaviour differences between several temperature signals  $\Rightarrow$  Inertial effects

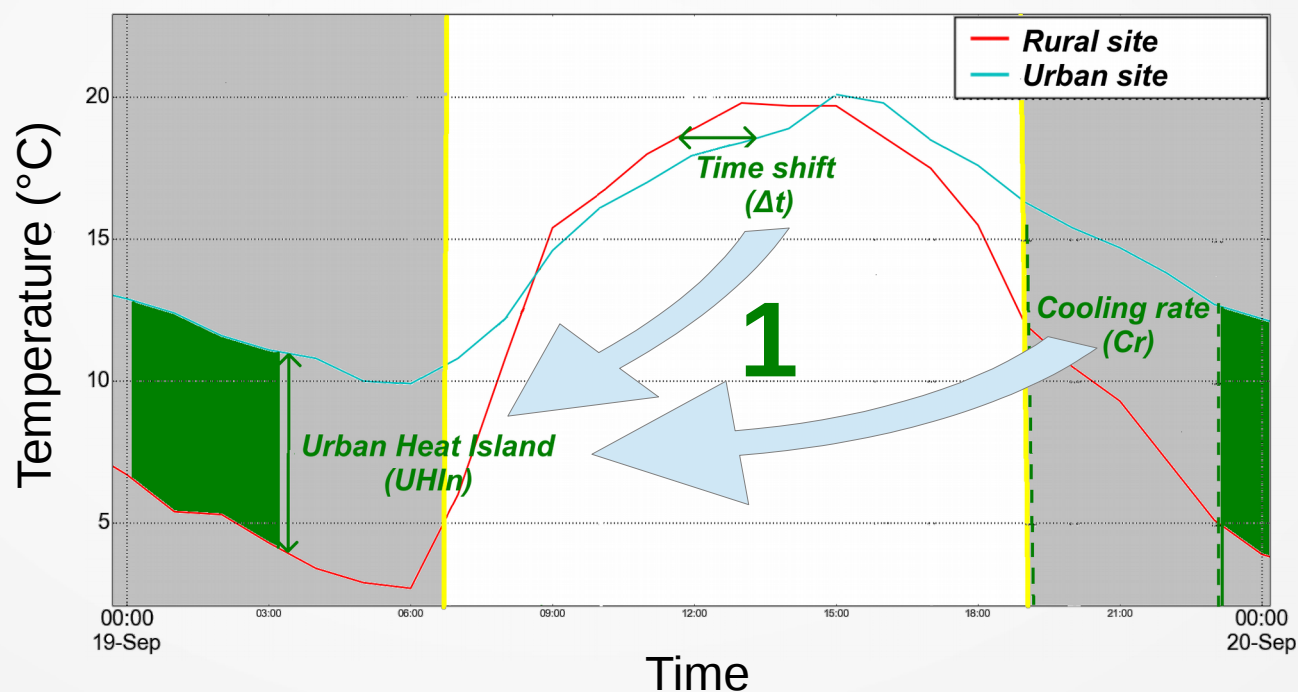
# Context

Observation : behaviour differences between several temperature signals  $\Rightarrow$  Inertial effects



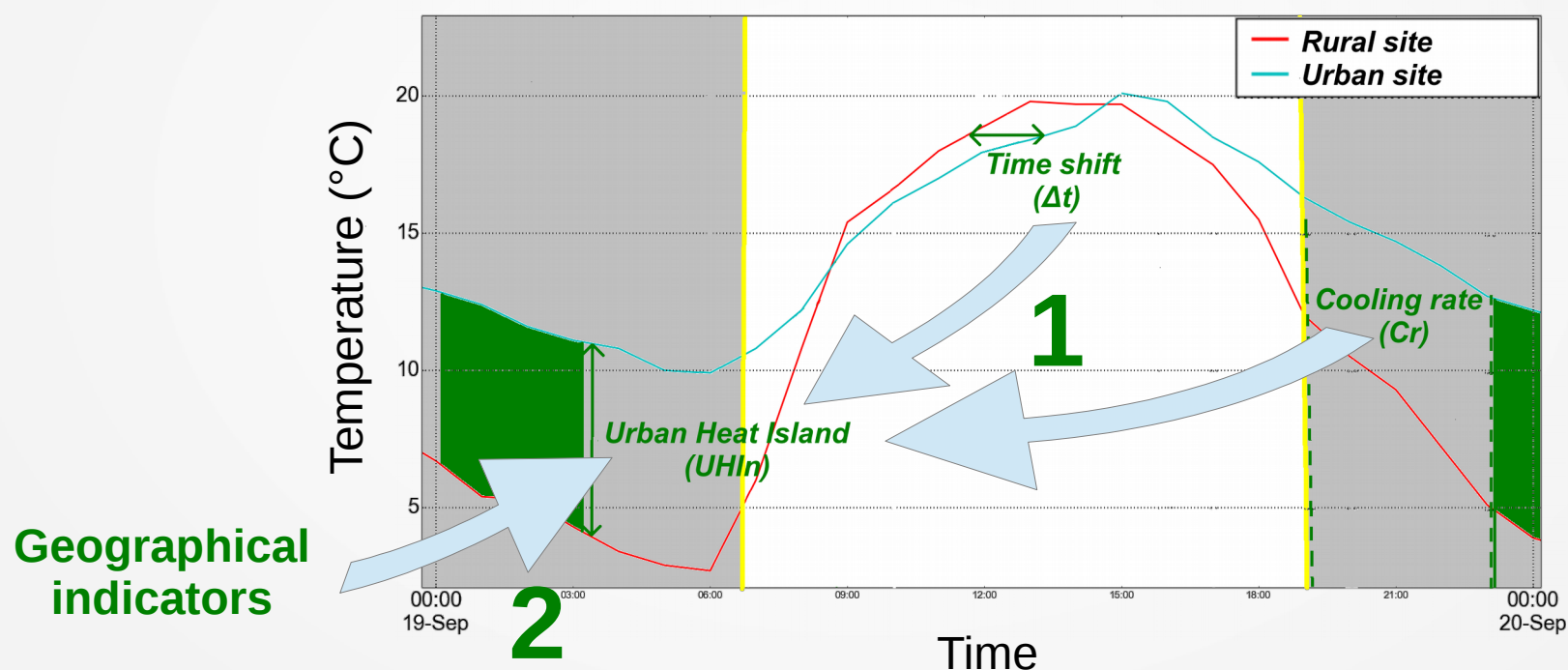
# Context

Observation : behaviour differences between several temperature signals  $\Rightarrow$  Inertial effects

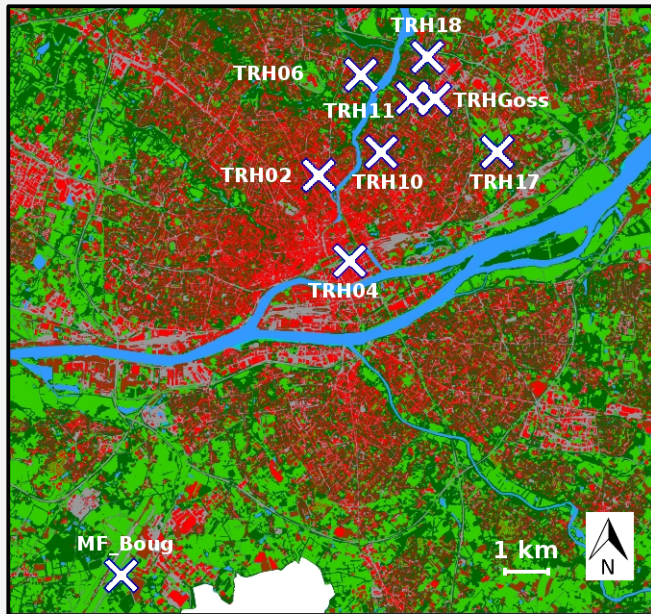


# Context

Observation : behaviour differences between several temperature signals  $\Rightarrow$  Inertial effects



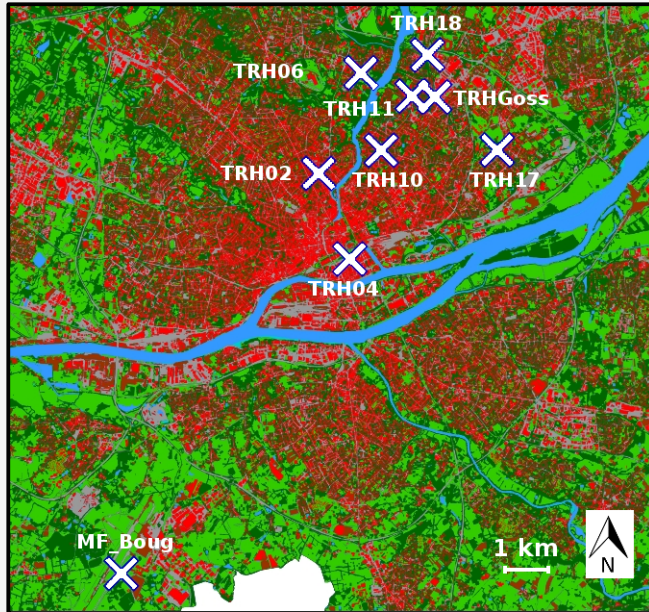
# Study area and equipment



20-24th July 2015

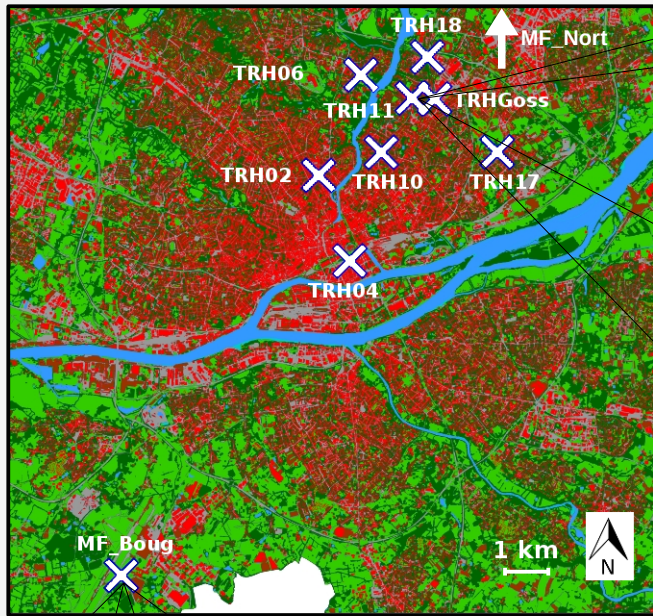


# Study area and equipment



Data are recorded  
for 4 years

# Study area and equipment



Data are recorded for 4 years

8 TRH stations



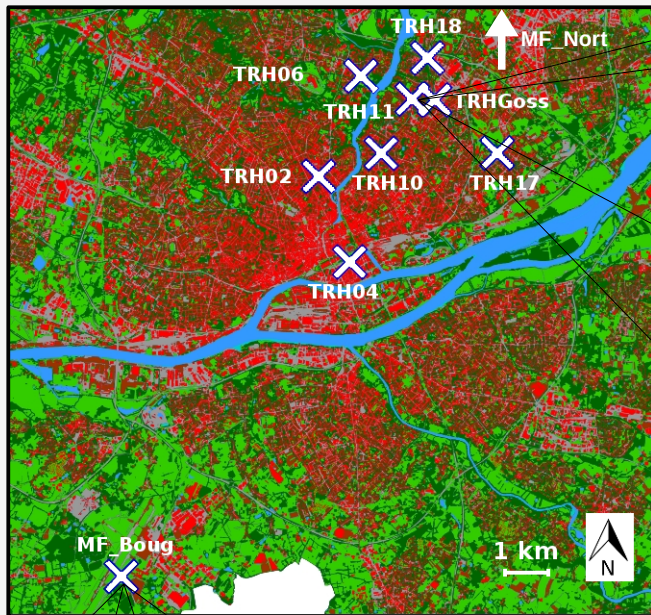
2 Meteo-France (MF) stations

20-24th July 2015





# Study area and equipment



Data are recorded for 4 years

8 TRH stations



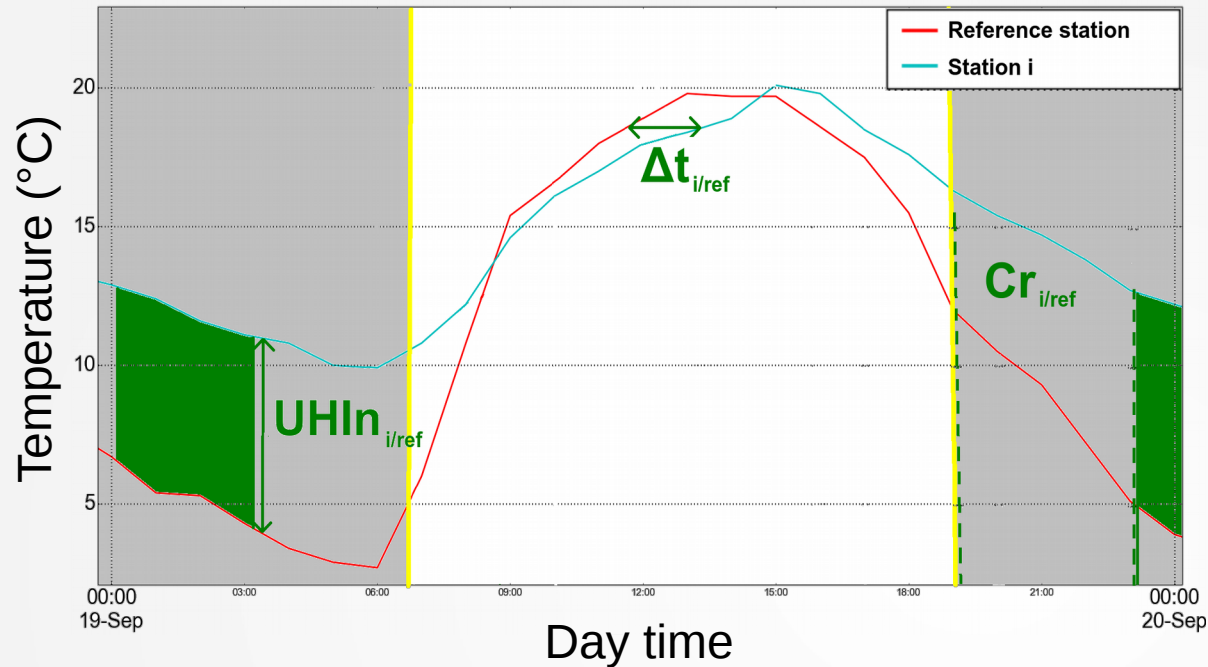
2 Meteo-France (MF) stations

Station	location	sampling time	sensor accuracy
TRH	mostly on walls	15 mins	+ - 0,3 K
MF	open sites	1h – linear interpolation every 15 mins	+ - 0,1 K

20-24th July 2015

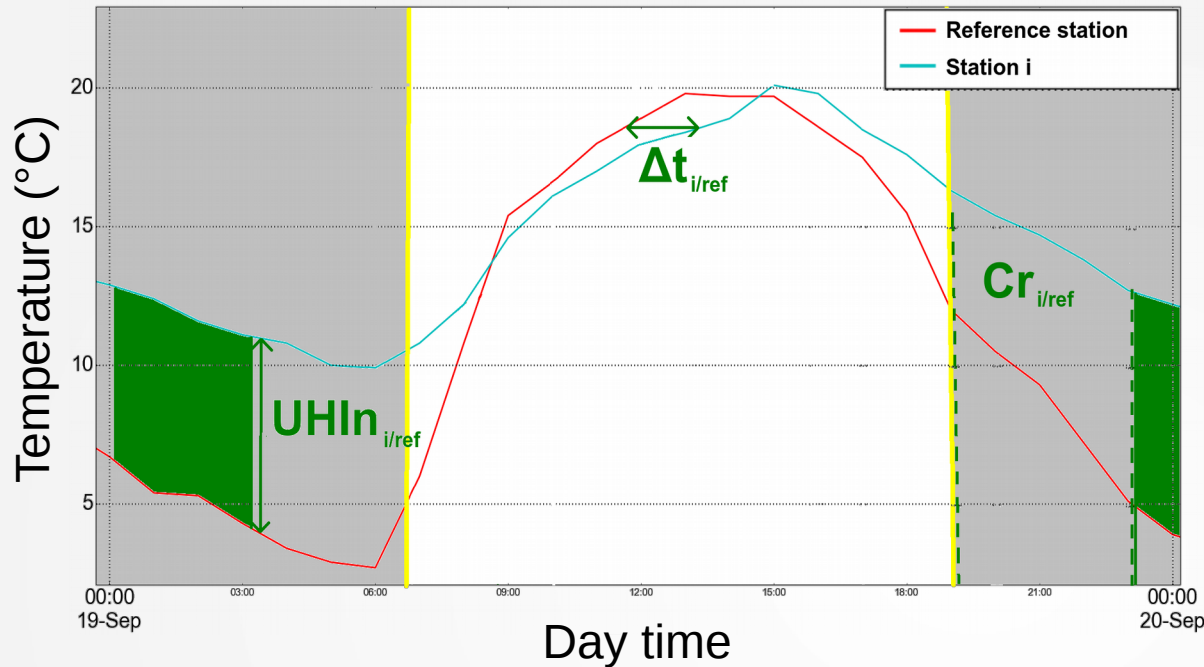


# Climate indicators calculation



Symbol	Indicator name	Unit	Time period	Equation
$\Delta t$	<b>Time shift</b>	mins	sunset+4h → sunset+8h	Index when the cross-correlation function is maximum
Cr	<b>Cooling rate</b>	°C/h	sunset → sunset+4h	mean temperature derivative difference
UHIn	<b>Night-time Urban Heat Island</b>	°C	all day	mean temperature difference

# Climate indicators calculation



→ A reference is used for each indicator calculation : "MF\_Boug"

→ Calculations are performed for each day

Symbol	Indicator name	Unit	Time period	Equation
$\Delta t$	<b>Time shift</b>	mins	sunset+4h → sunset+8h	Index when the cross-correlation function is maximum
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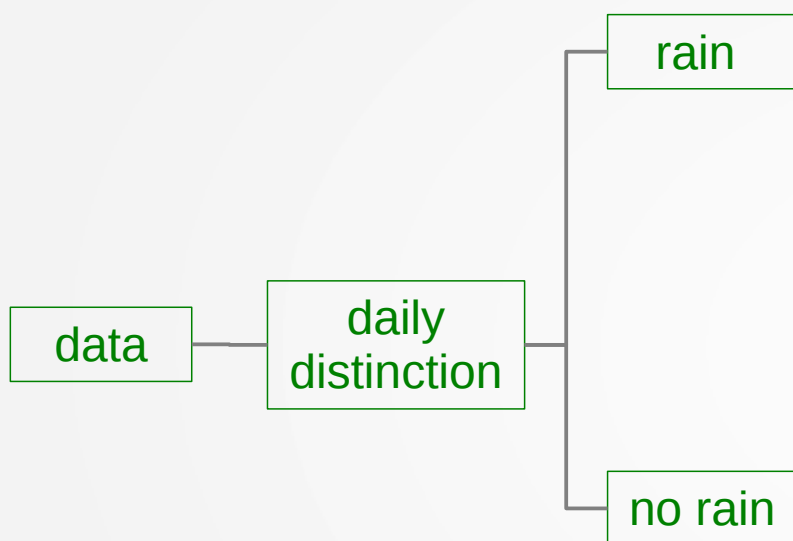
# Season / weather conditions filtering

data

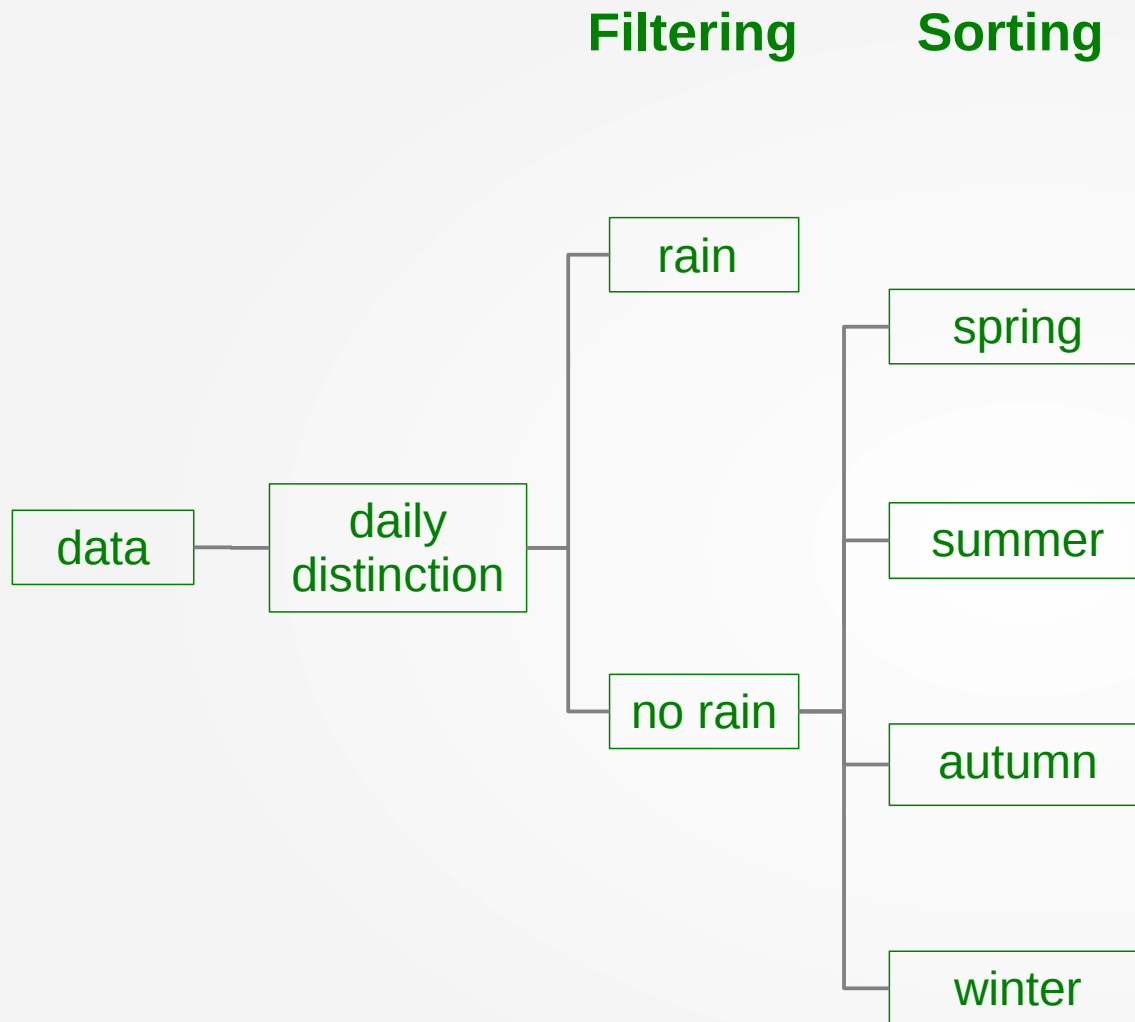
daily  
distinction

# Season / weather conditions filtering

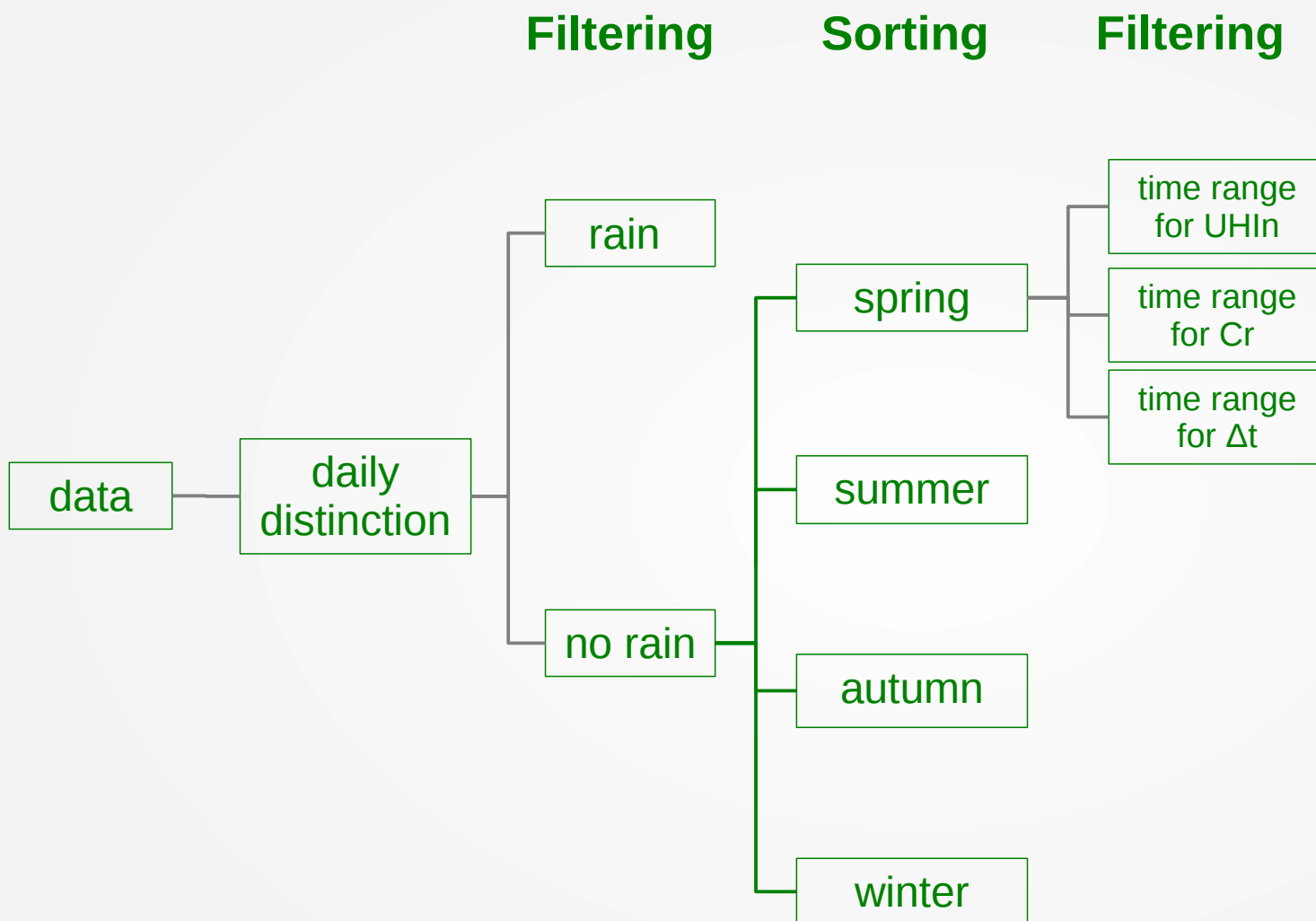
## Filtering



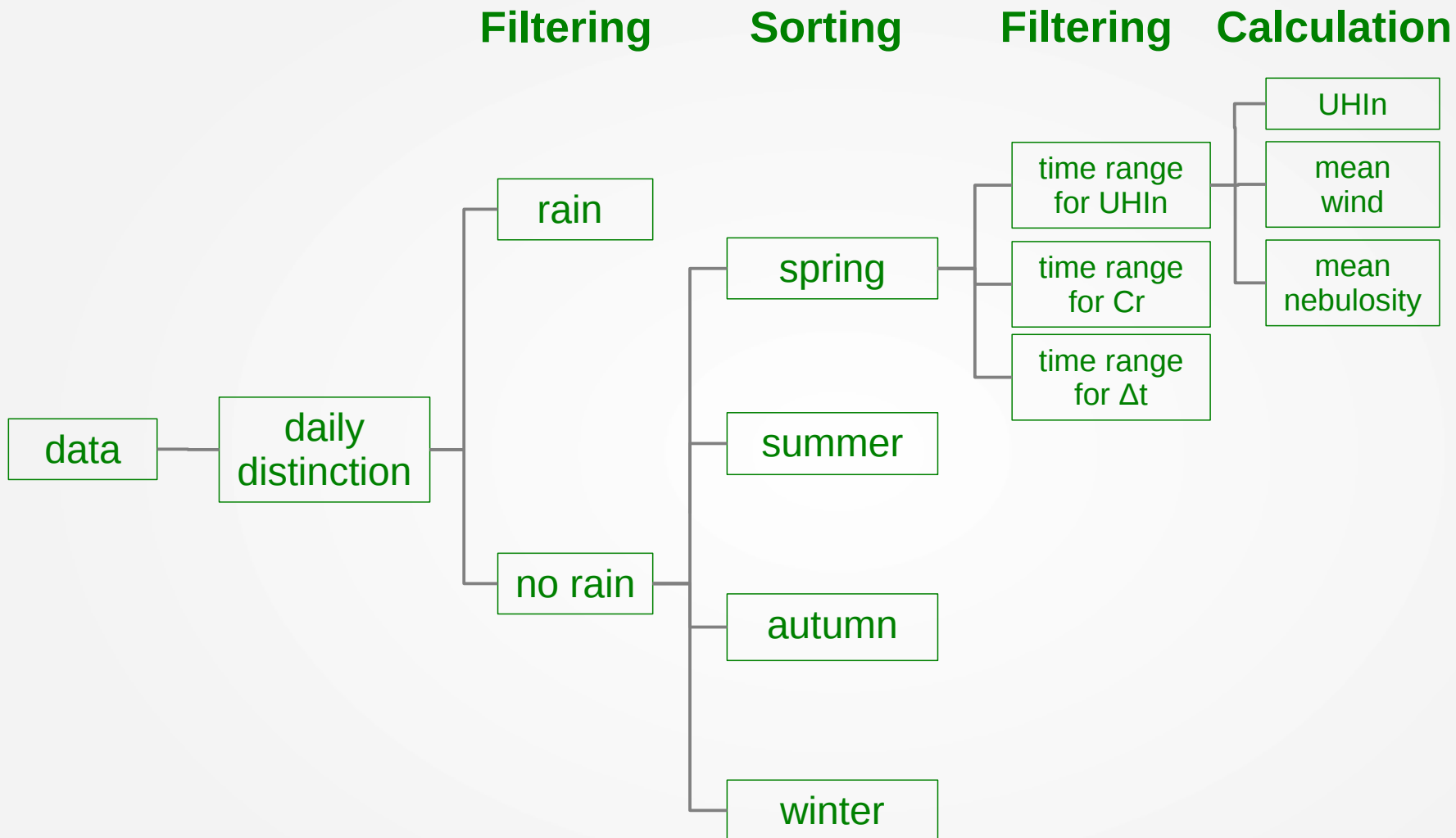
# Season / weather conditions filtering



# Season / weather conditions filtering

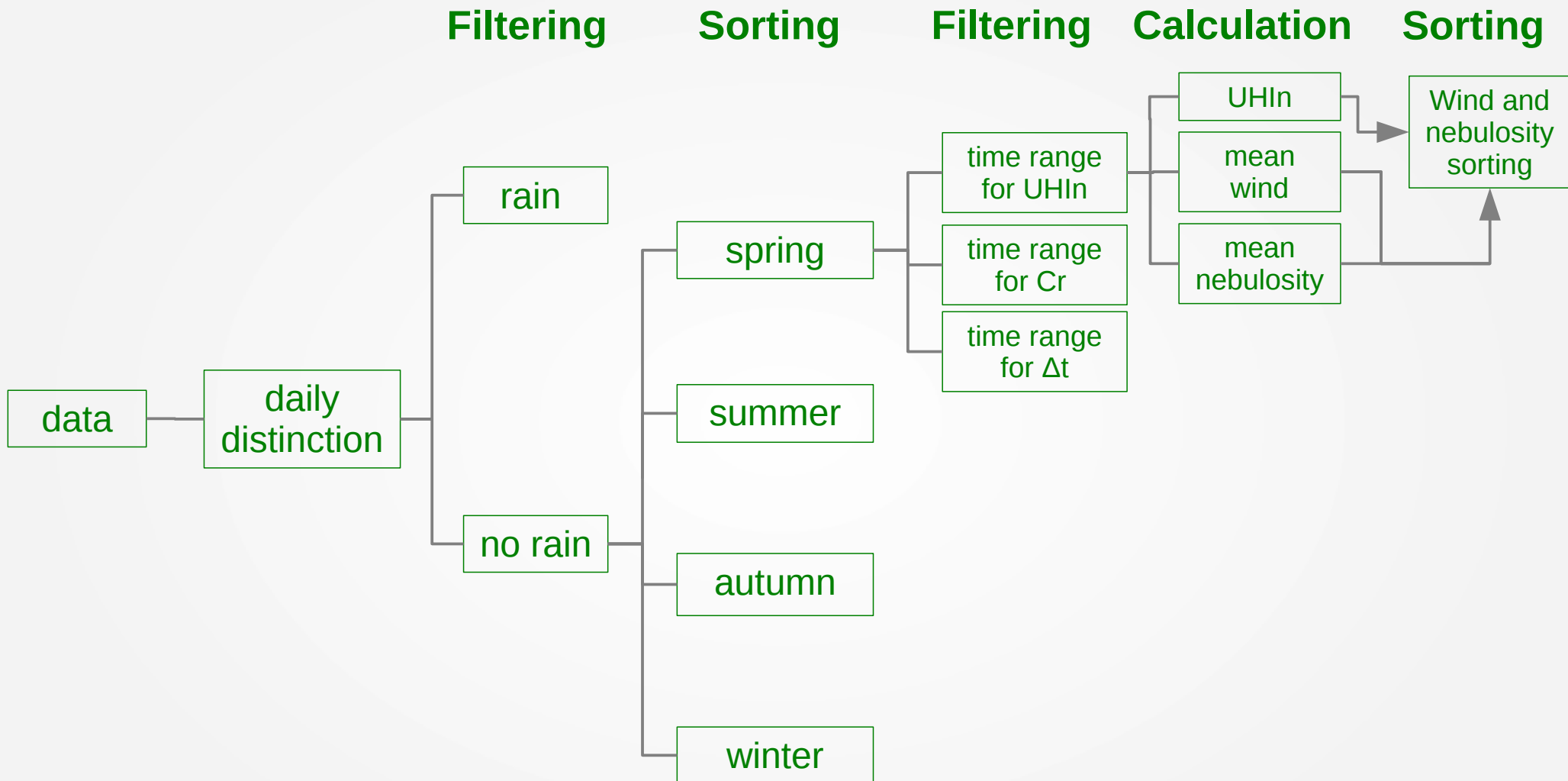


# Season / weather conditions filtering

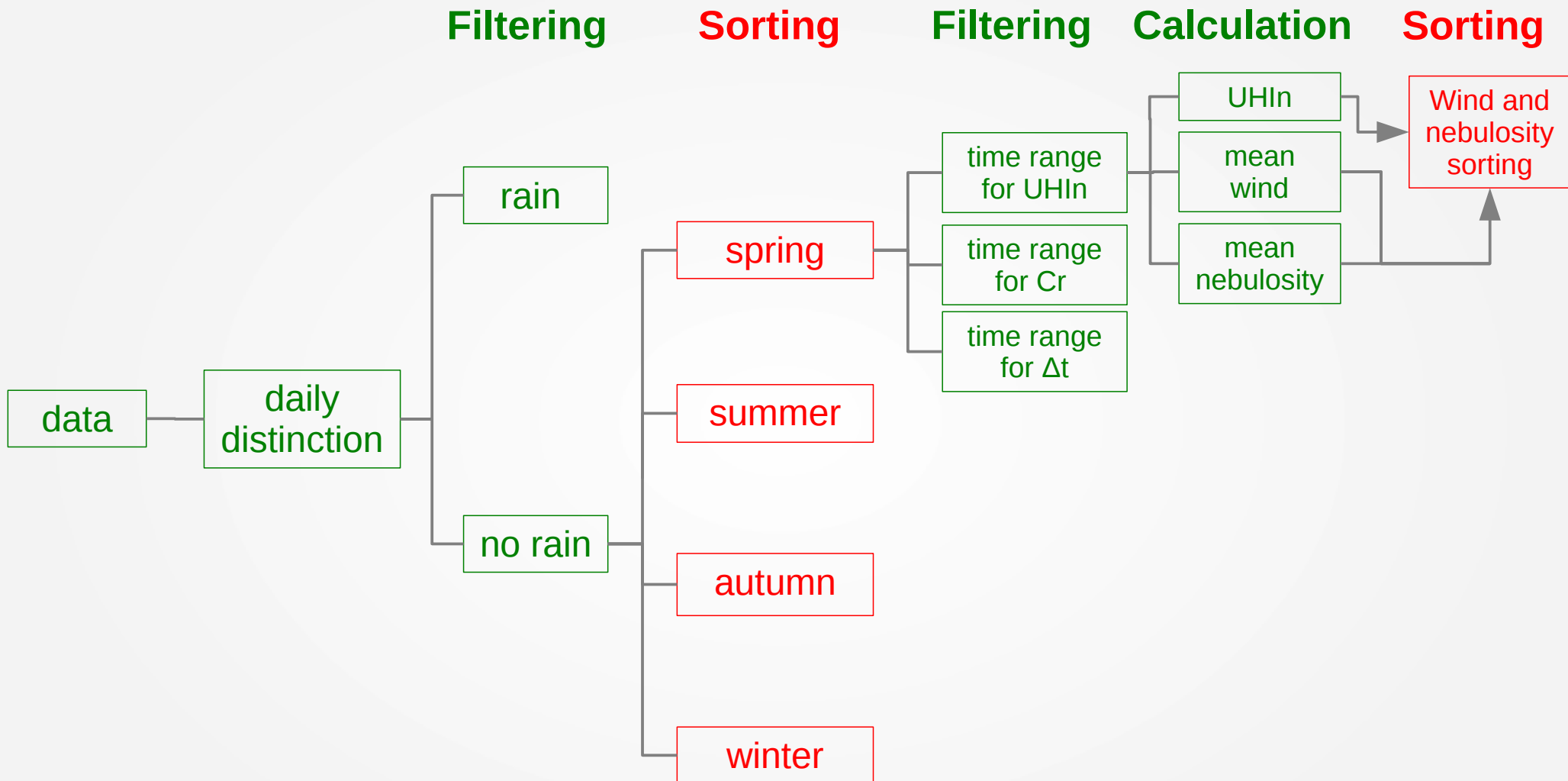




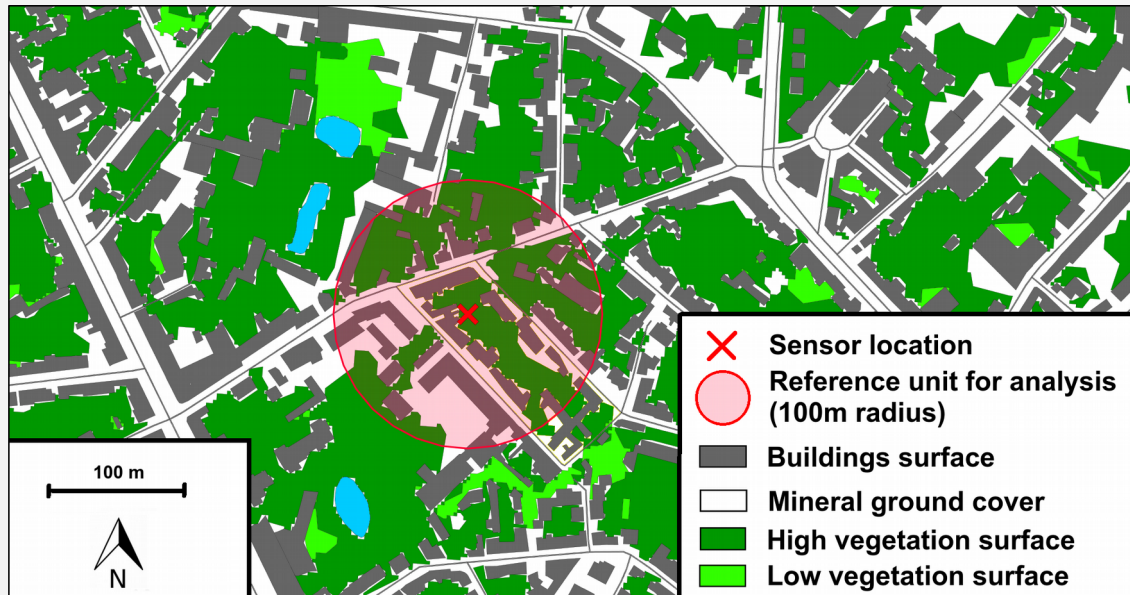
# Season / weather conditions filtering



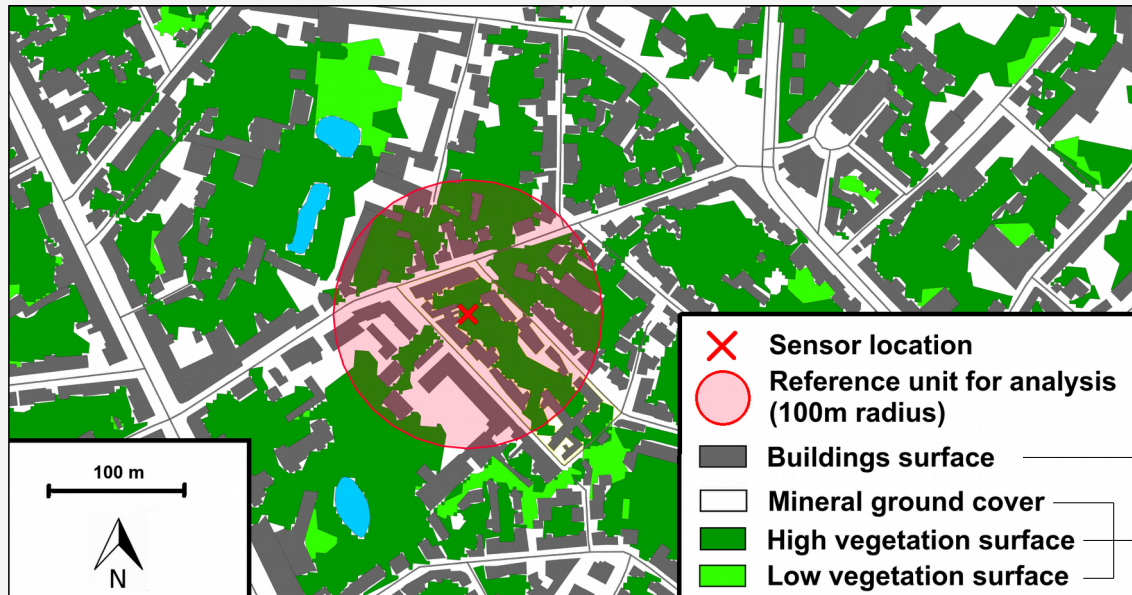
# Season / weather conditions filtering



# Geographical indicators calculation



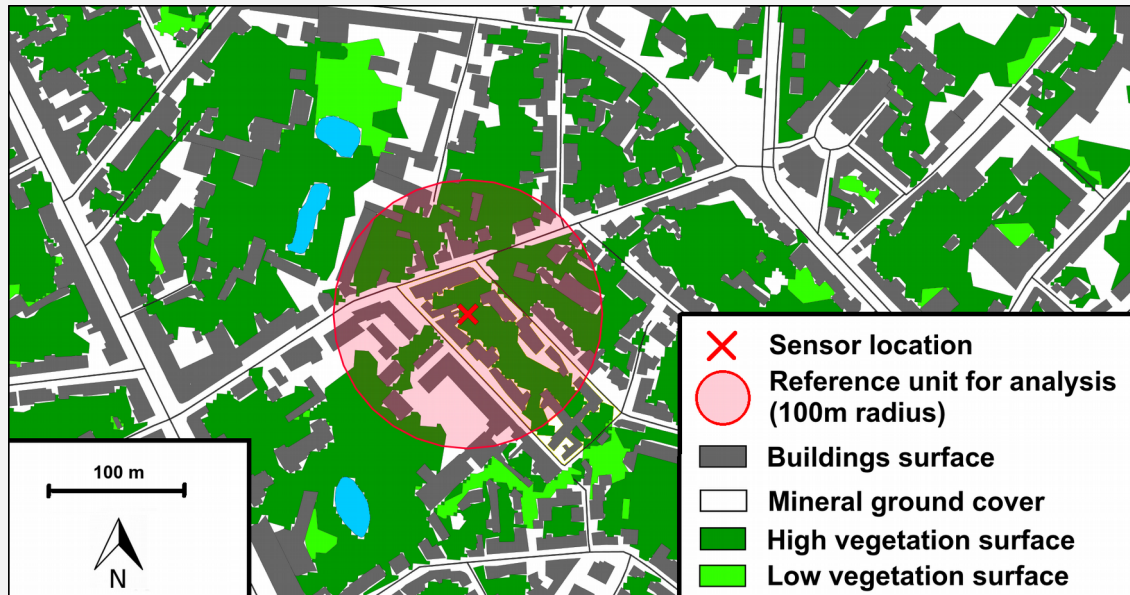
# Geographical indicators calculation



BD TOPO - IGN - 2013

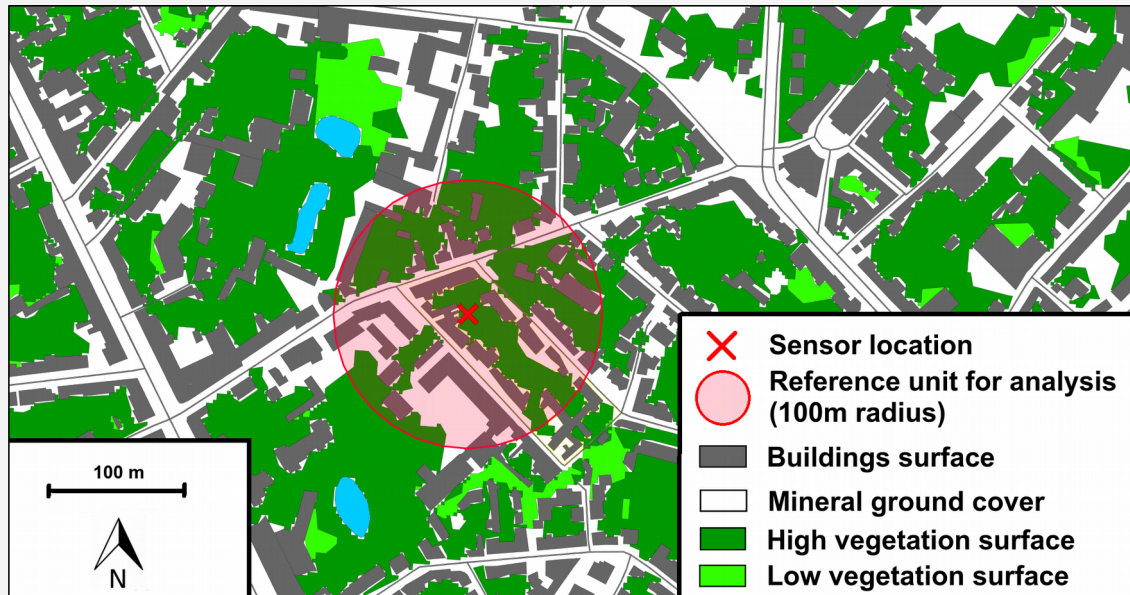
SPOT image - 2.5 m resolution - 2004

# Geographical indicators calculation



- Calculated indicators:
- Average building height
  - **Linear of facade density**
  - Open space area
  - Building volume density
  - Facade density
  - Vegetation density
  - **Equivalent admittance**

# Geographical indicators calculation



- Calculated indicators:
- Average building height
  - **Linear of facade density**
  - Open space area
  - Building volume density
  - Facade density
  - Vegetation density
  - **Equivalent admittance**

Symbol	Name	Formula
$D_{Flin}$	Linear of facade density	$\frac{\sum_i p_i}{A_{ref}}$
ADM	Equivalent admittance	$\mu_a \cdot (D_{Flin} \cdot h_w + \frac{a_{ai}}{A_{ref}}) + \mu_{vh} \cdot \frac{a_{vhi}}{A_{ref}} + \mu_{vl} \cdot \frac{a_{vli}}{A_{ref}}$

$A_{ref}$  : buffer circle area (m<sup>2</sup>)

$p_i$  : perimeter of the building  $i$

$a_{vh_i}$  : area taken by the high vegetation  $i$

$a_{vl_i}$  : area taken by the low vegetation  $i$

$a_{bg_i}$  : area taken by the bare ground  $i$

$a_{a_i}$  : area taken by the artificial surface  $i$

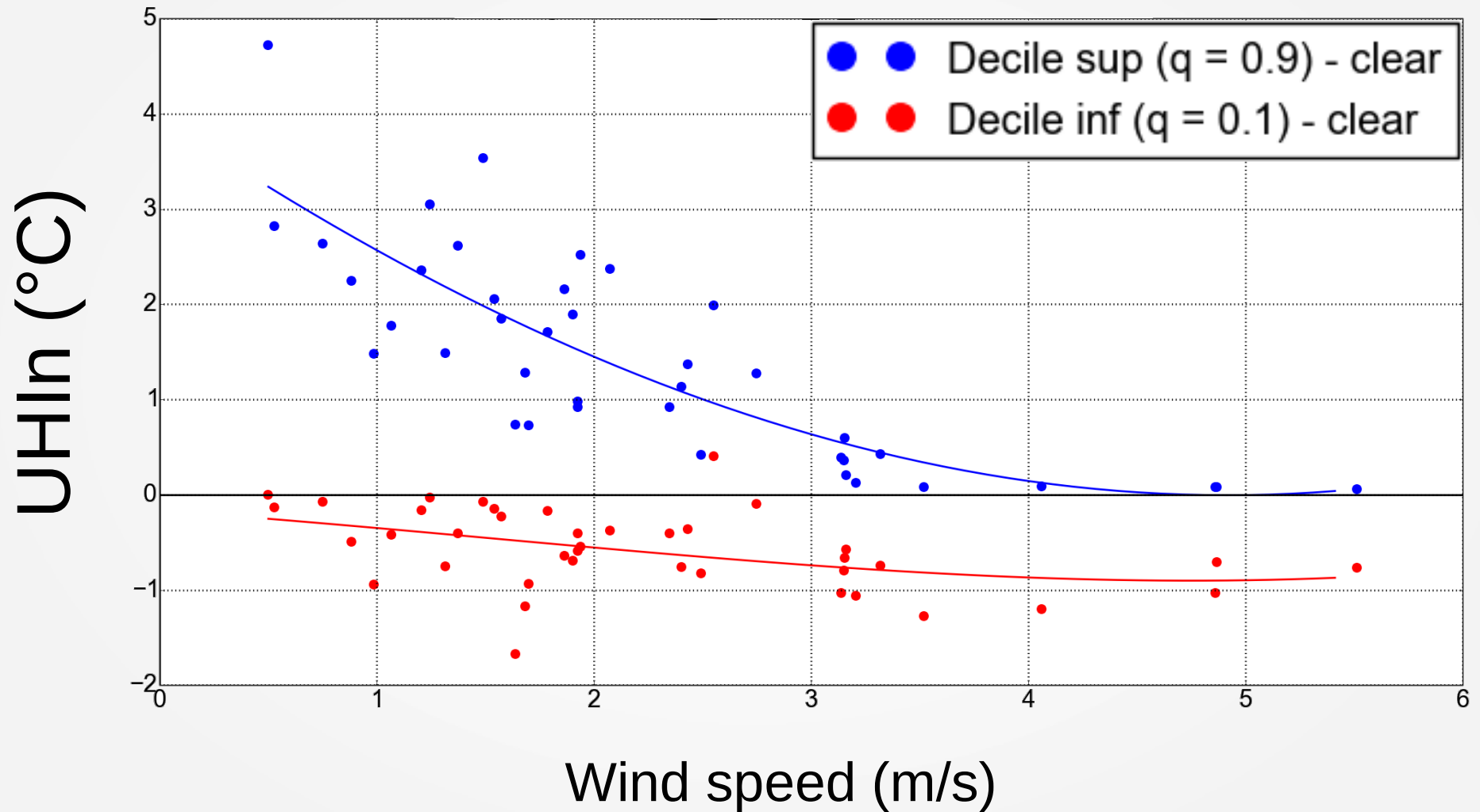
$\mu_a = 700$ ,  $\mu_{vl} = 175$ ,  $\mu_{vh} = 350$  :

thermal admittance for artificial surfaces, low vegetation and high vegetation (J.m<sup>-2</sup>.s<sup>-1/2</sup>.K<sup>-1</sup>)

$h_w = 3$  : wall height to consider as influent on the air temperature at screen height

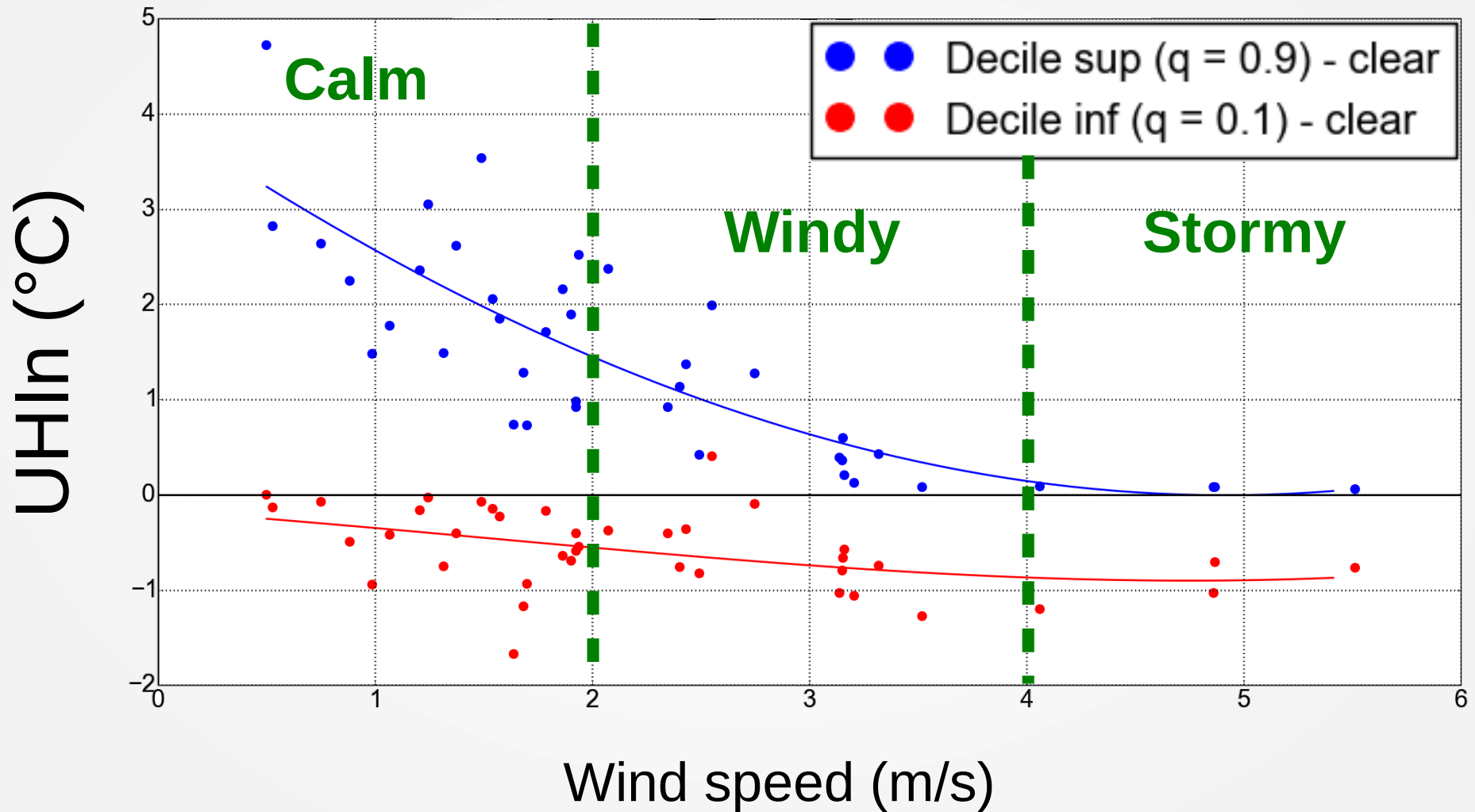
# Wind speed classification

(Spring)



# Wind speed classification

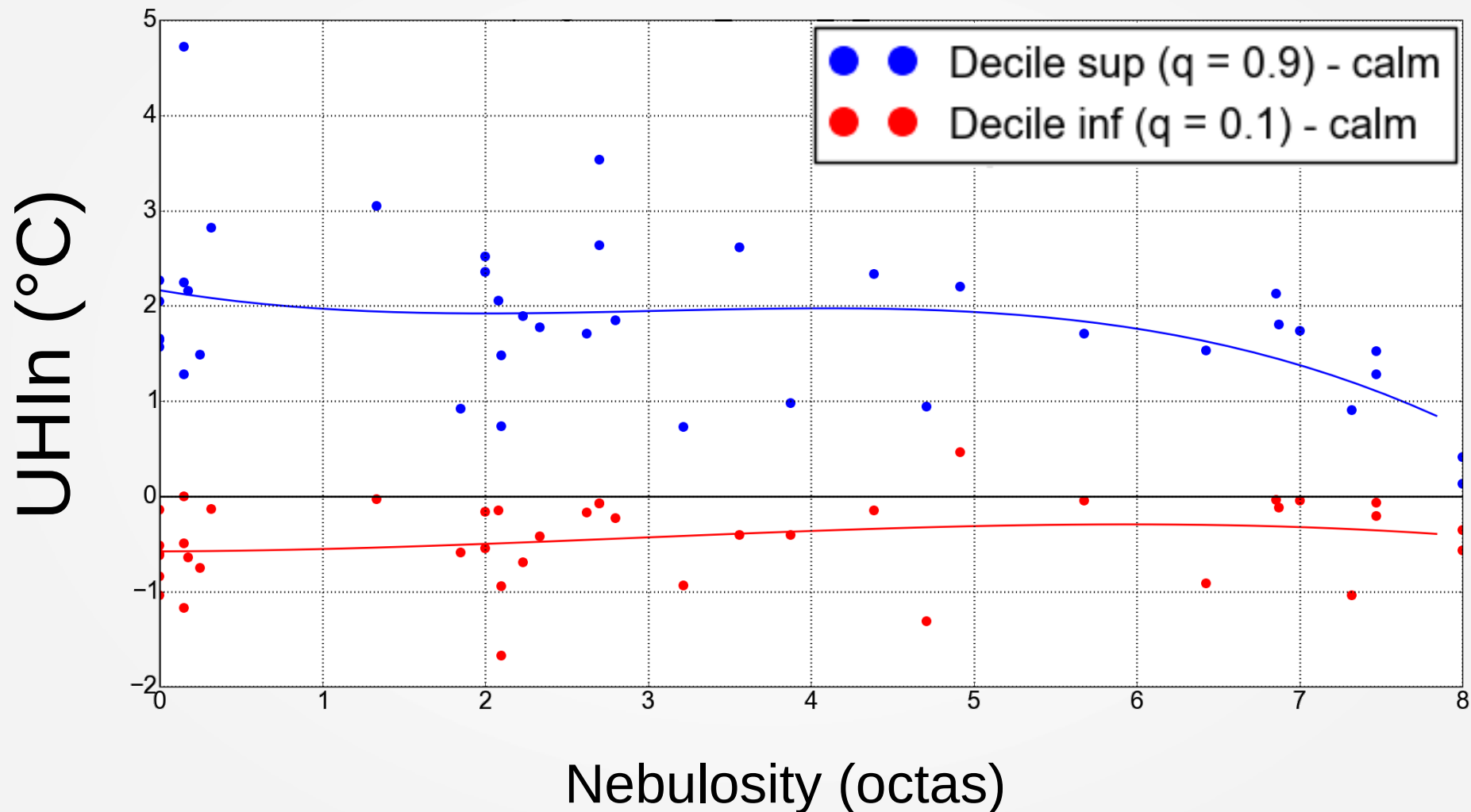
(Spring)





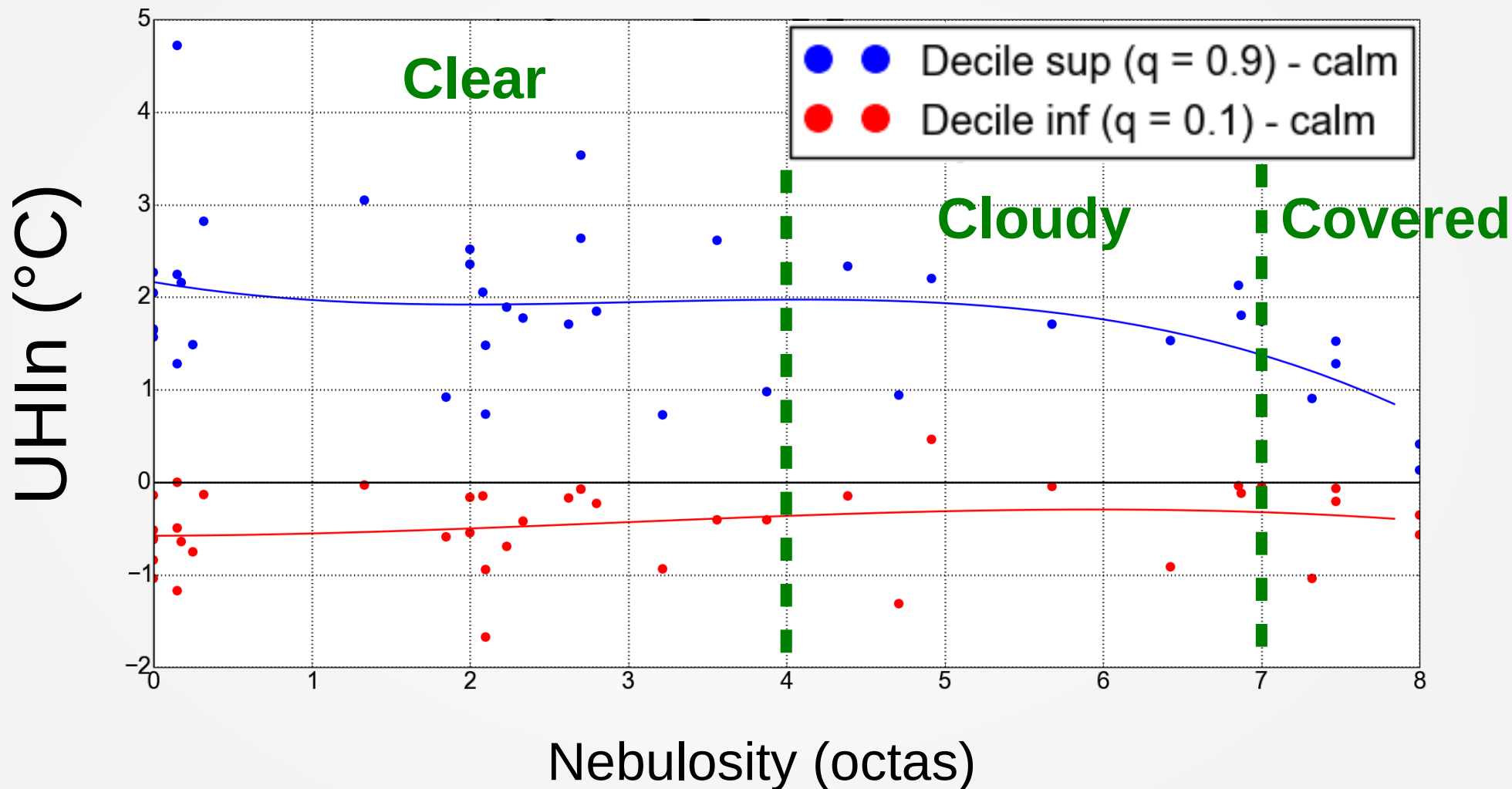
# Nebulosity classification

(Spring)

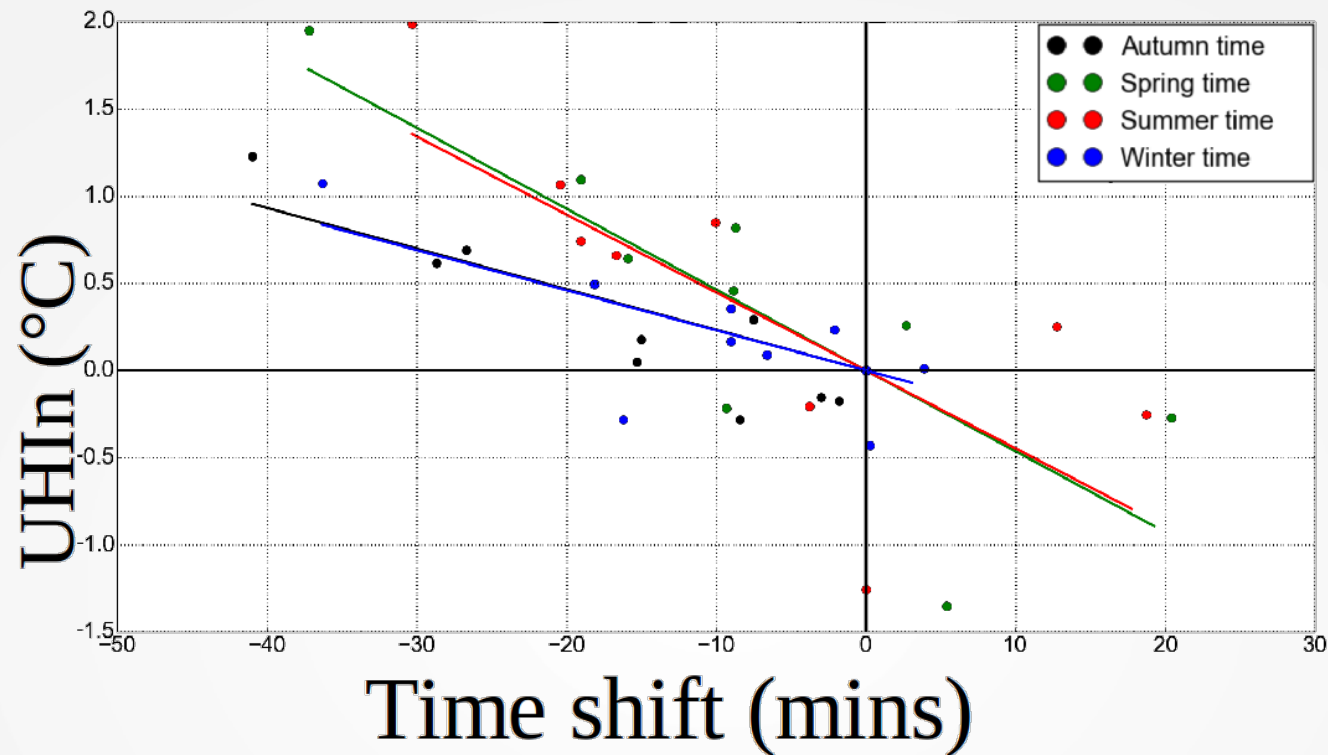


# Nebulosity classification

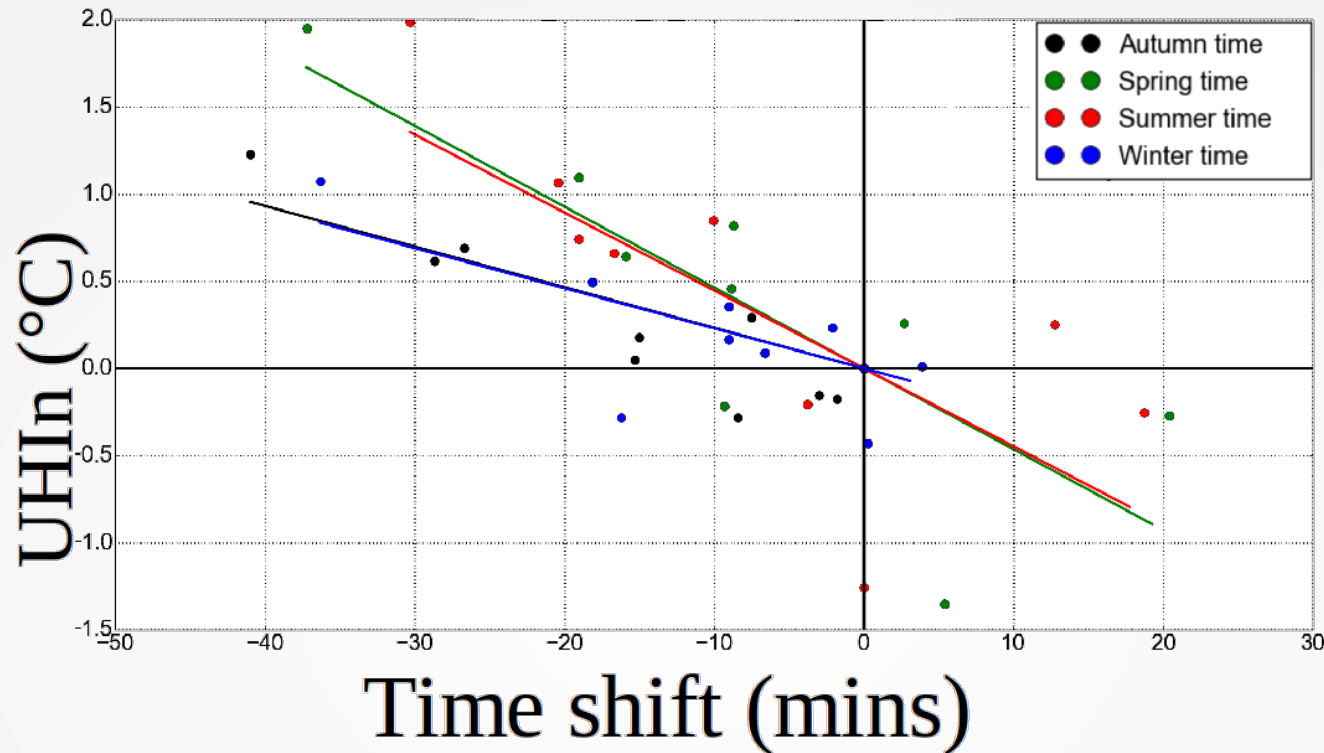
(Spring)



# Interclimatic indicators regression

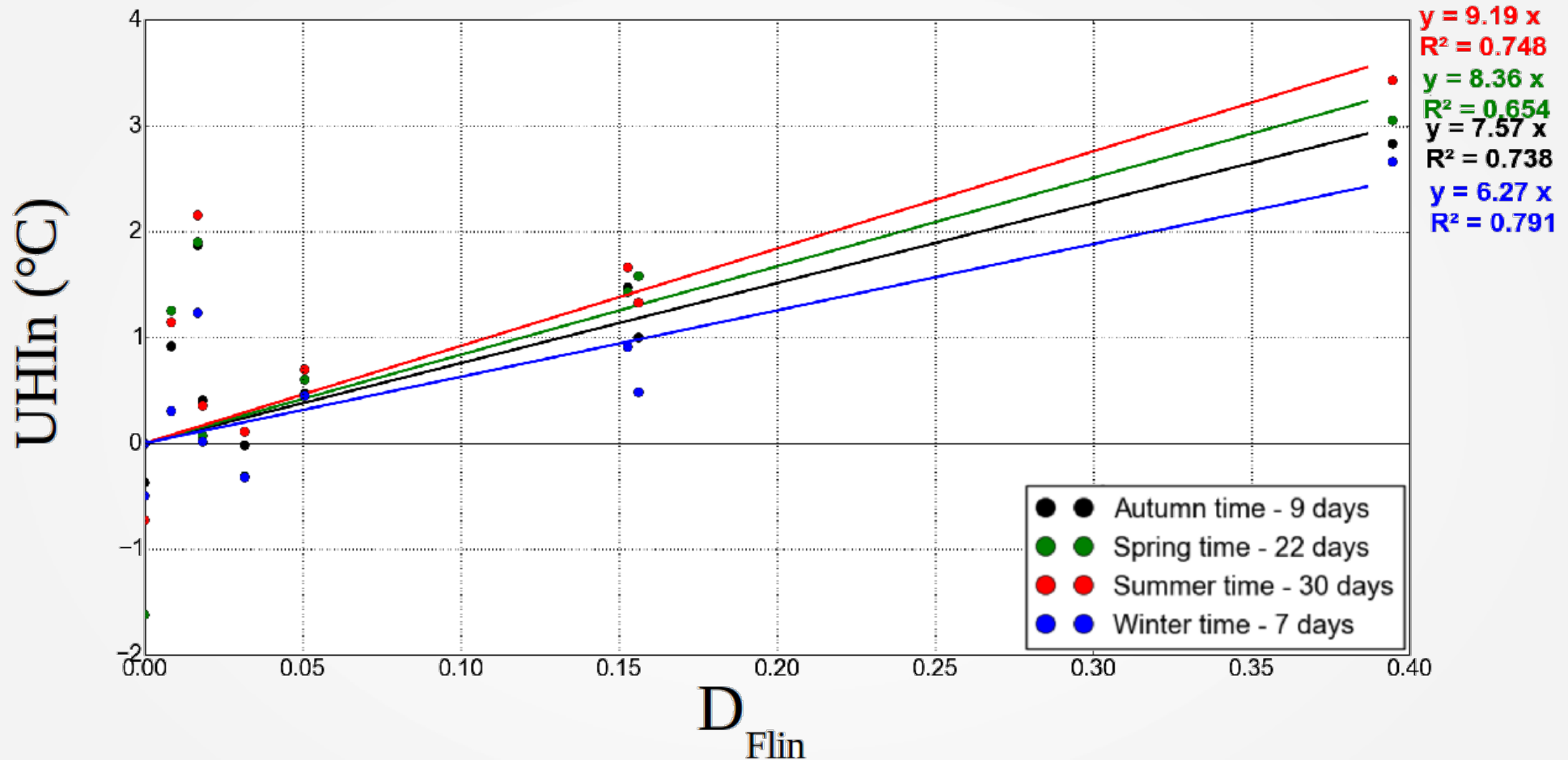


# Interclimatic indicators regression

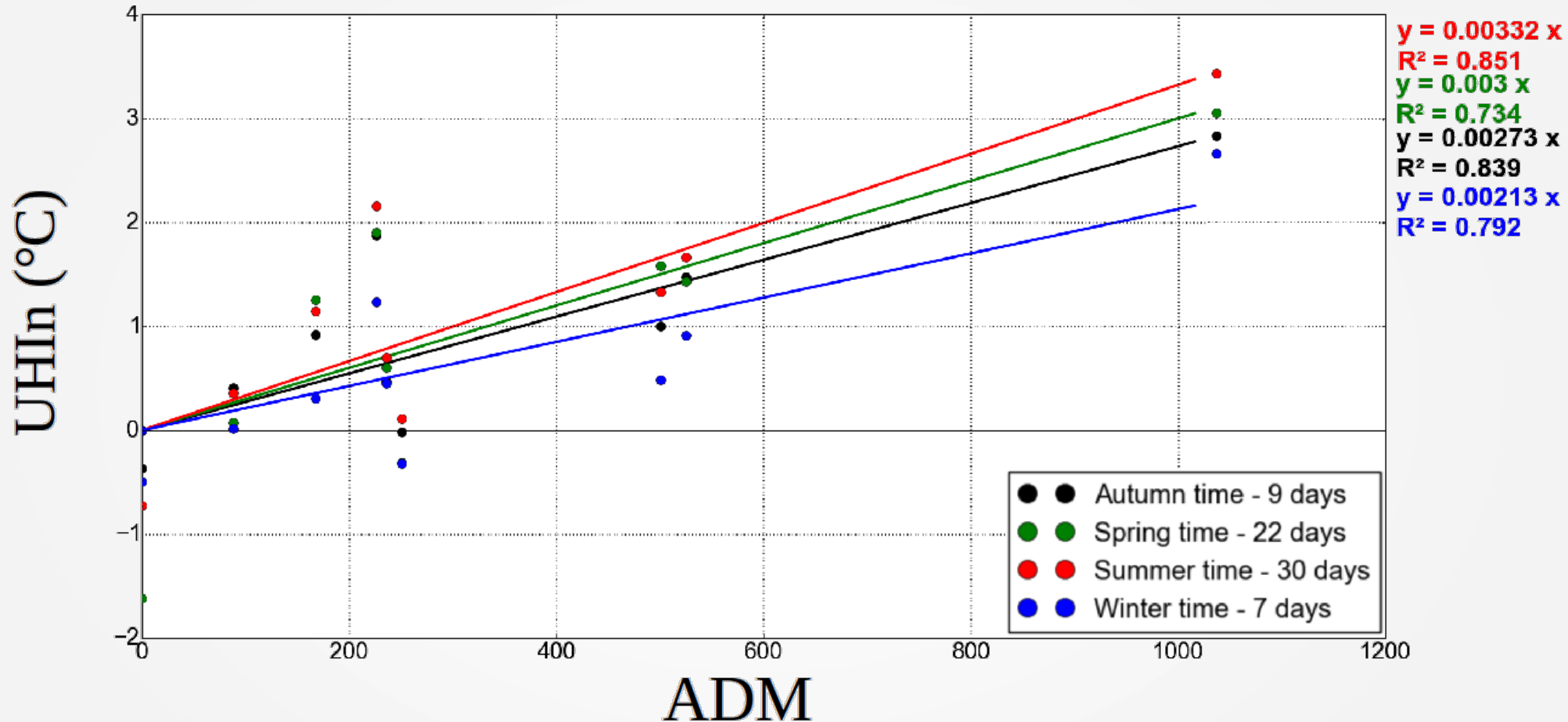


- The slope of the regression is modified by the season and the weather conditions
- $R^2$  is good (most of the time  $> 0,6$ ) – 0,94 and 0,90 between UHIln and Cr respectively for summer and autumn time (clear and calm conditions)  
⇒ the 4 hours after sunset seem decisive for UHI formation

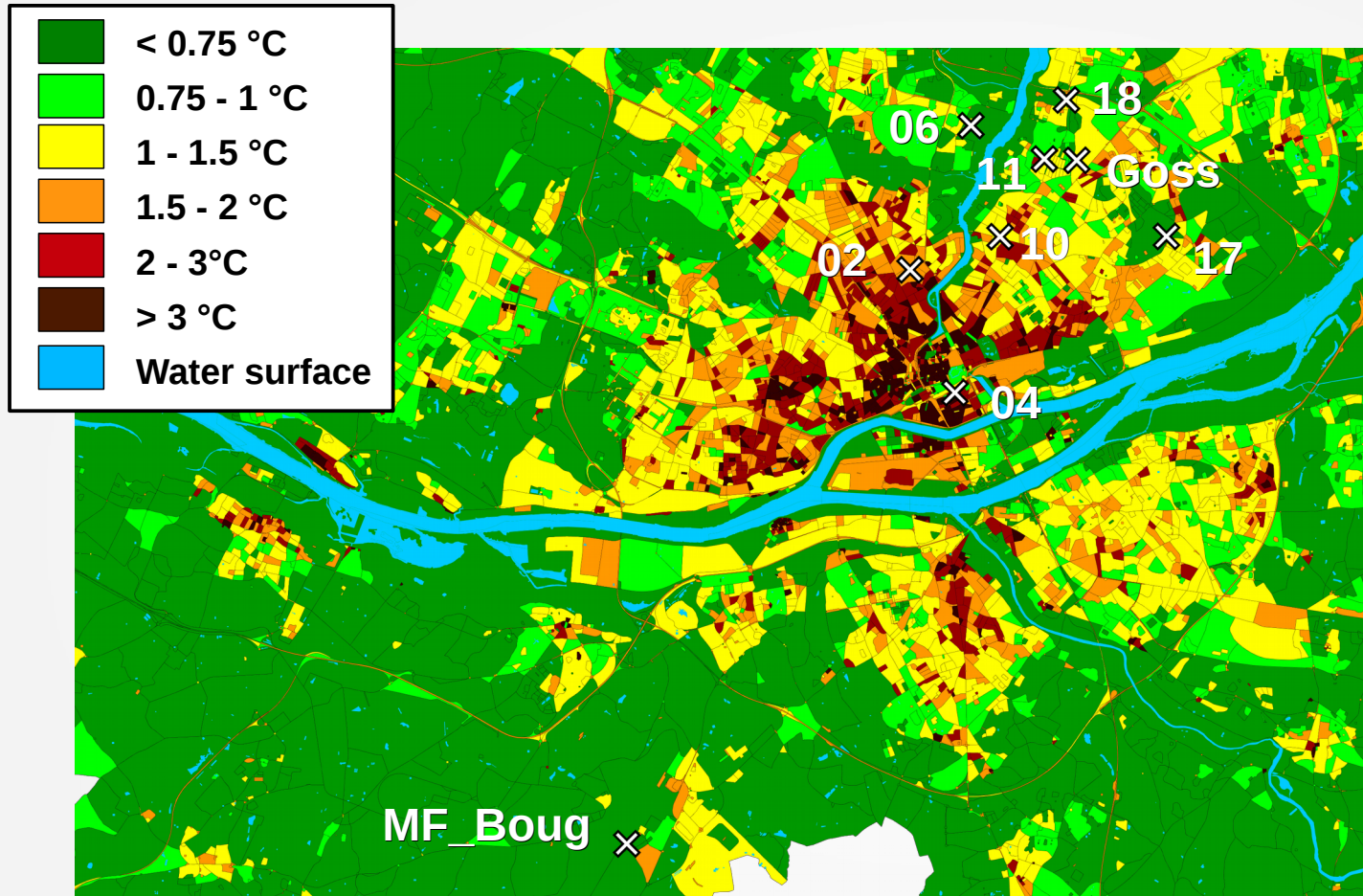
# UHI<sub>In</sub> versus geographical indicators



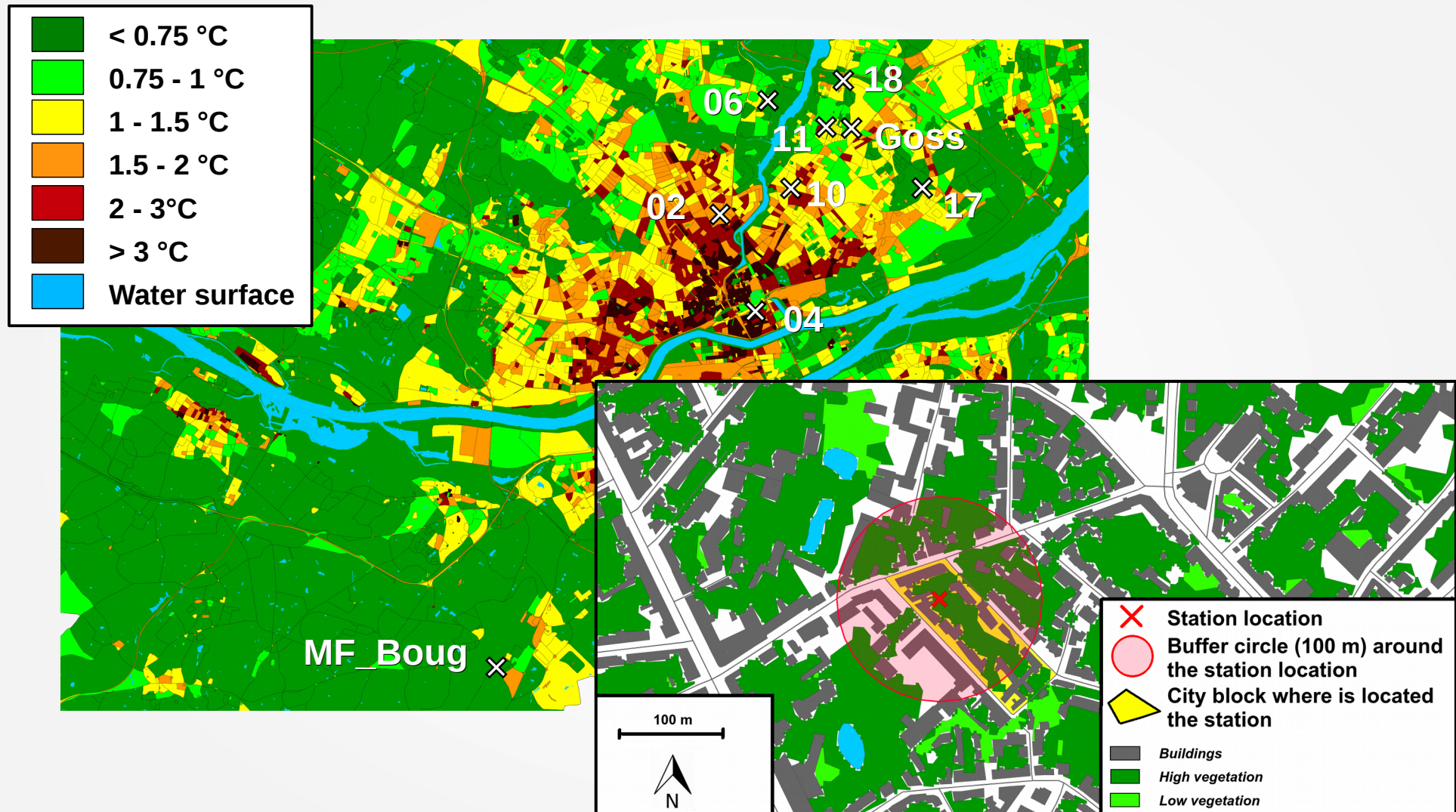
# UHI<sub>in</sub> versus geographical indicators



# Application of the results on Nantes

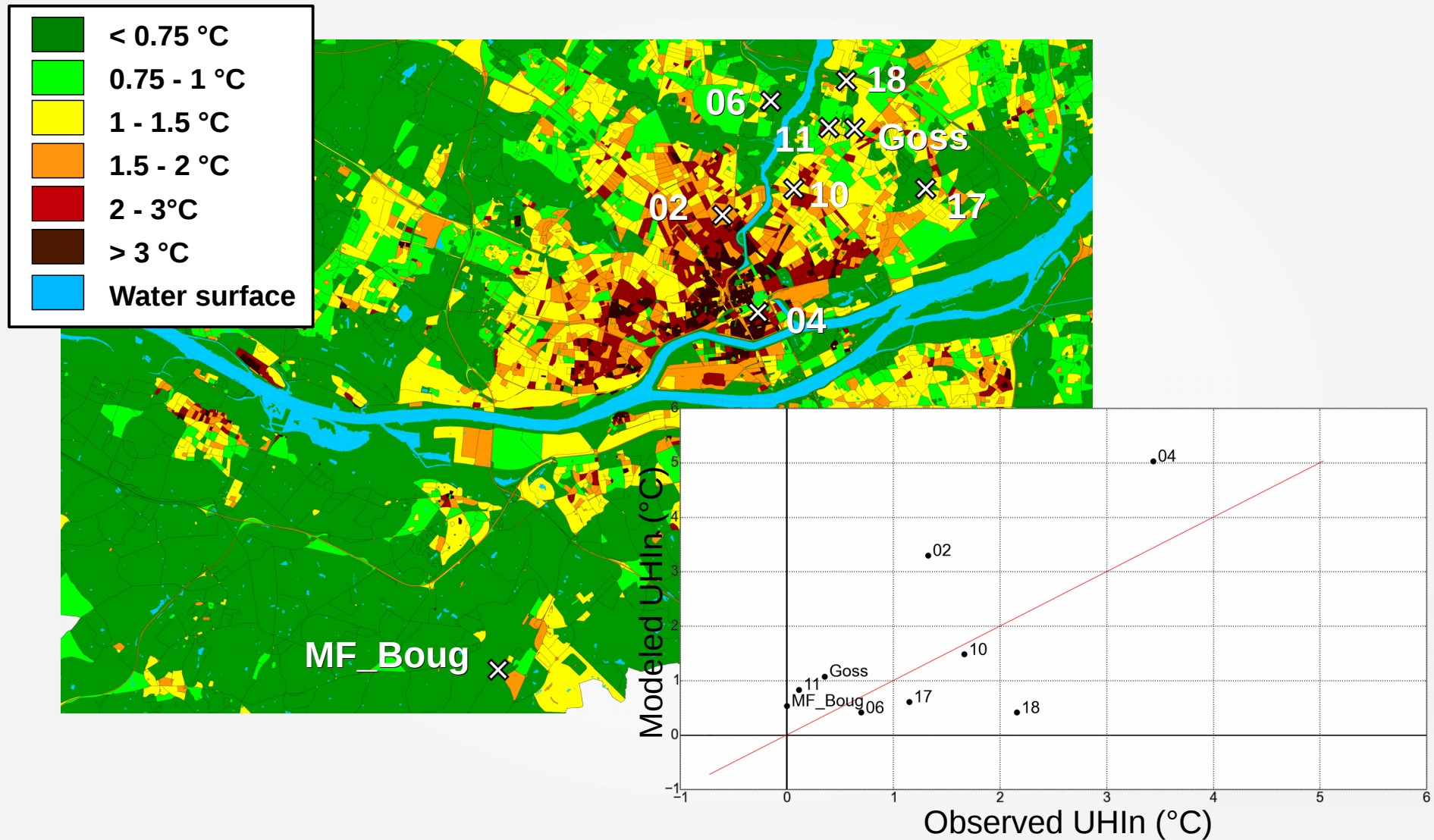


# Application of the results on Nantes

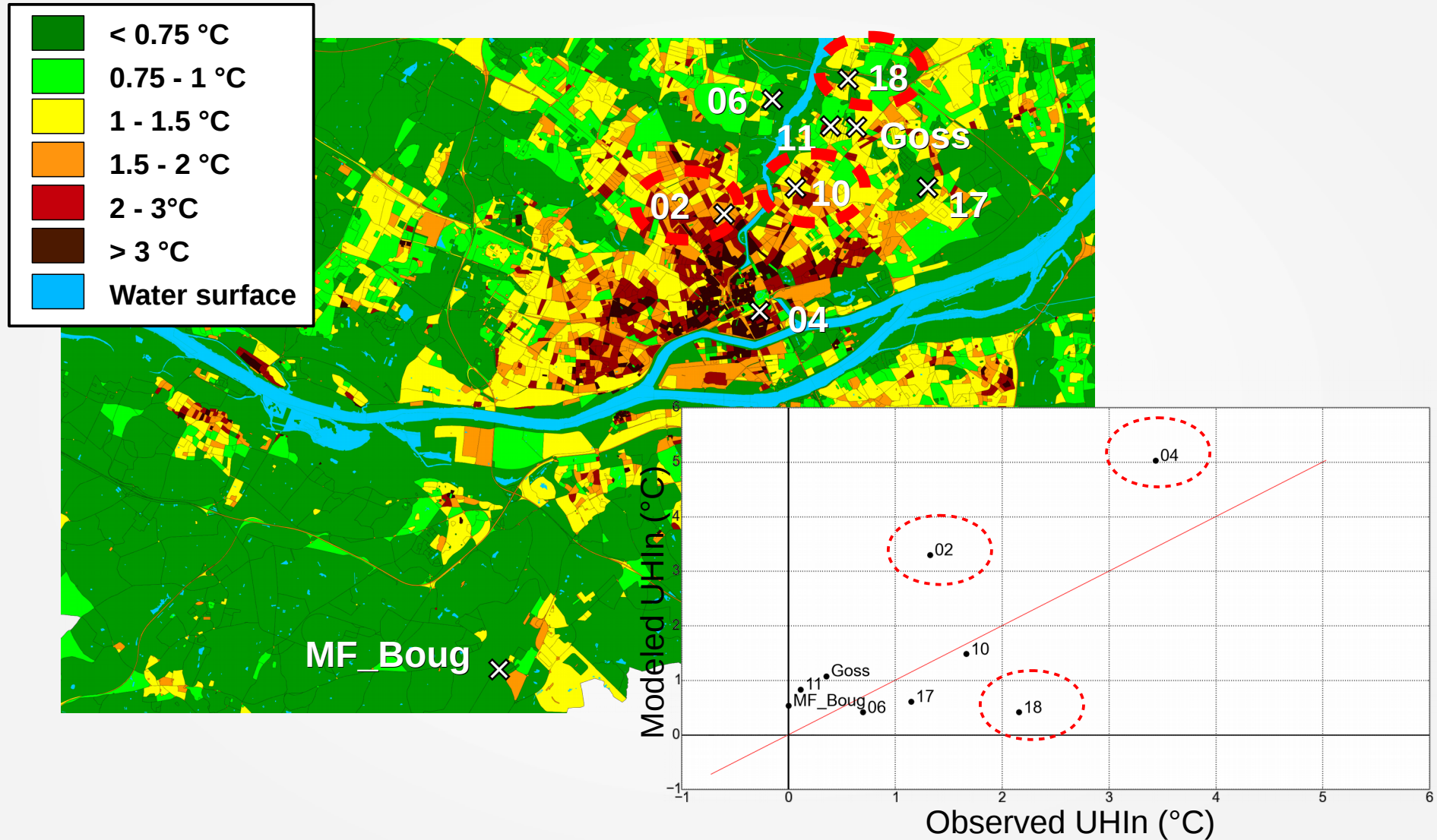




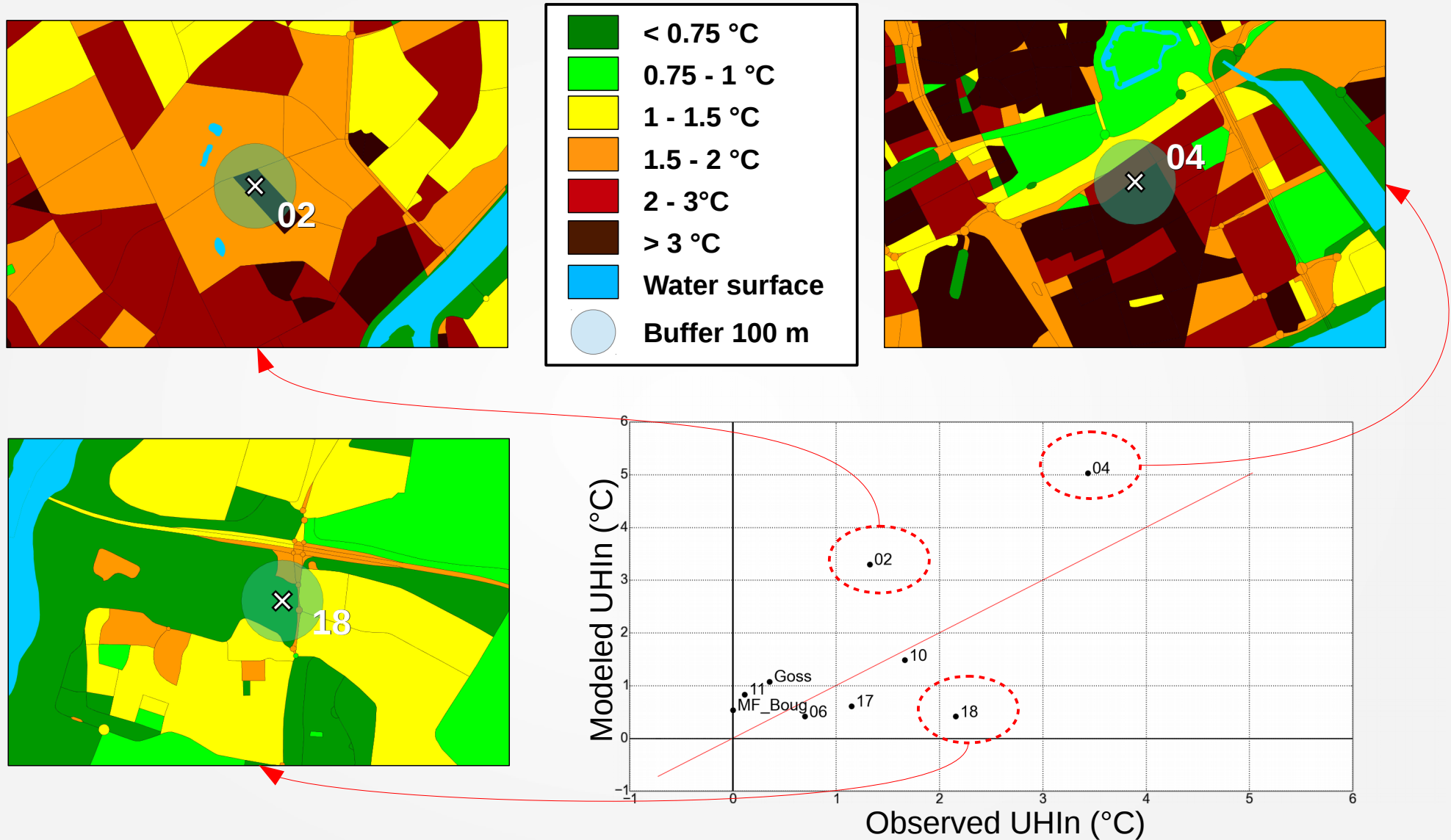
# Application of the results on Nantes



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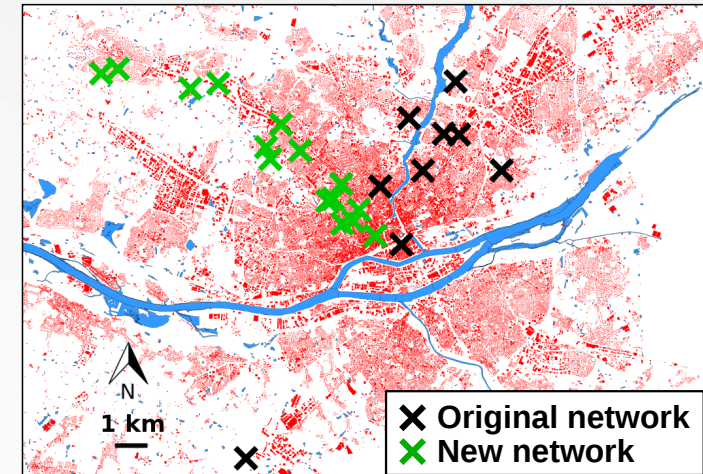
# Application of the results on Nantes



# Further improvements

## → Climatic measurement :

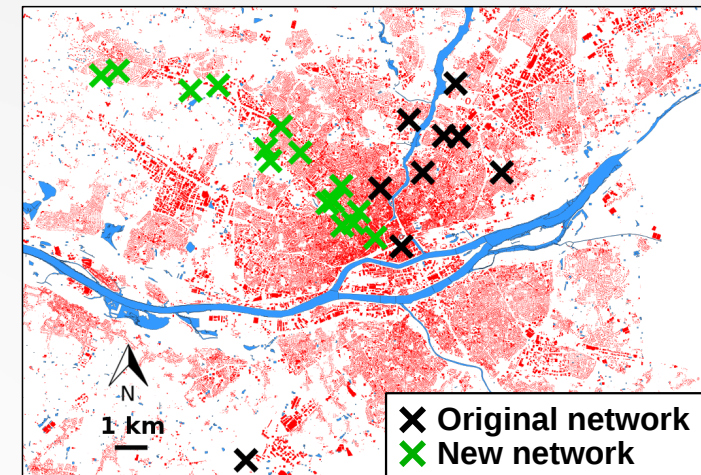
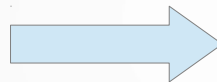
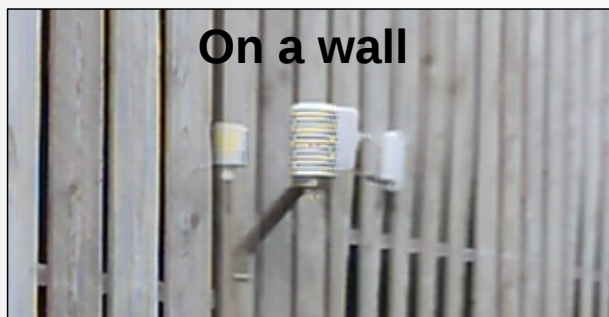
- Increase the number of measurement sites (currently too low for good regression analysis)



# Further improvements

## → Climatic measurement :

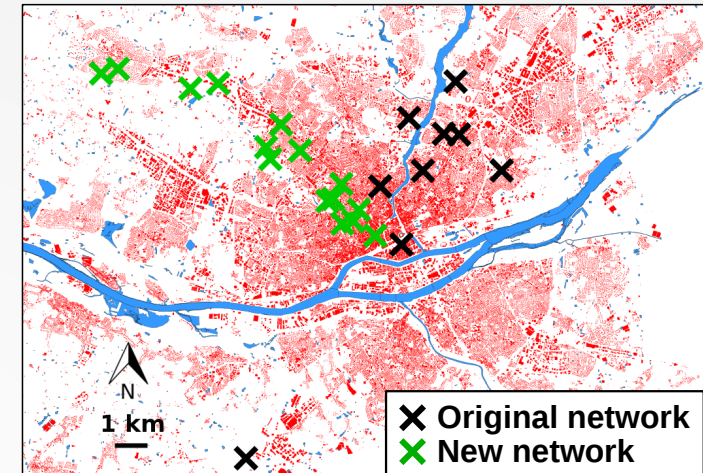
- Increase the number of measurement sites (currently too low for good regression analysis)
- Use poles far from urban surfaces for sensor location
- Improve the knowledge about shield issues



# Further improvements

## → Climatic measurement :

- Increase the number of measurement sites (currently too low for good regression analysis)
- Use poles far from urban surfaces for sensor location
- Improve the knowledge about shield issues



## → Geographical part : evaluate the influence on the results of :

- The size and the shape (LCZ, buffer circle, city block defined from road network) choice of the spatial reference unit;
- The accuracy of the data (remote sensing image resolution) and the errors led by the use of different sources of data

# Acknowledgements

**Thank you for your attention !**

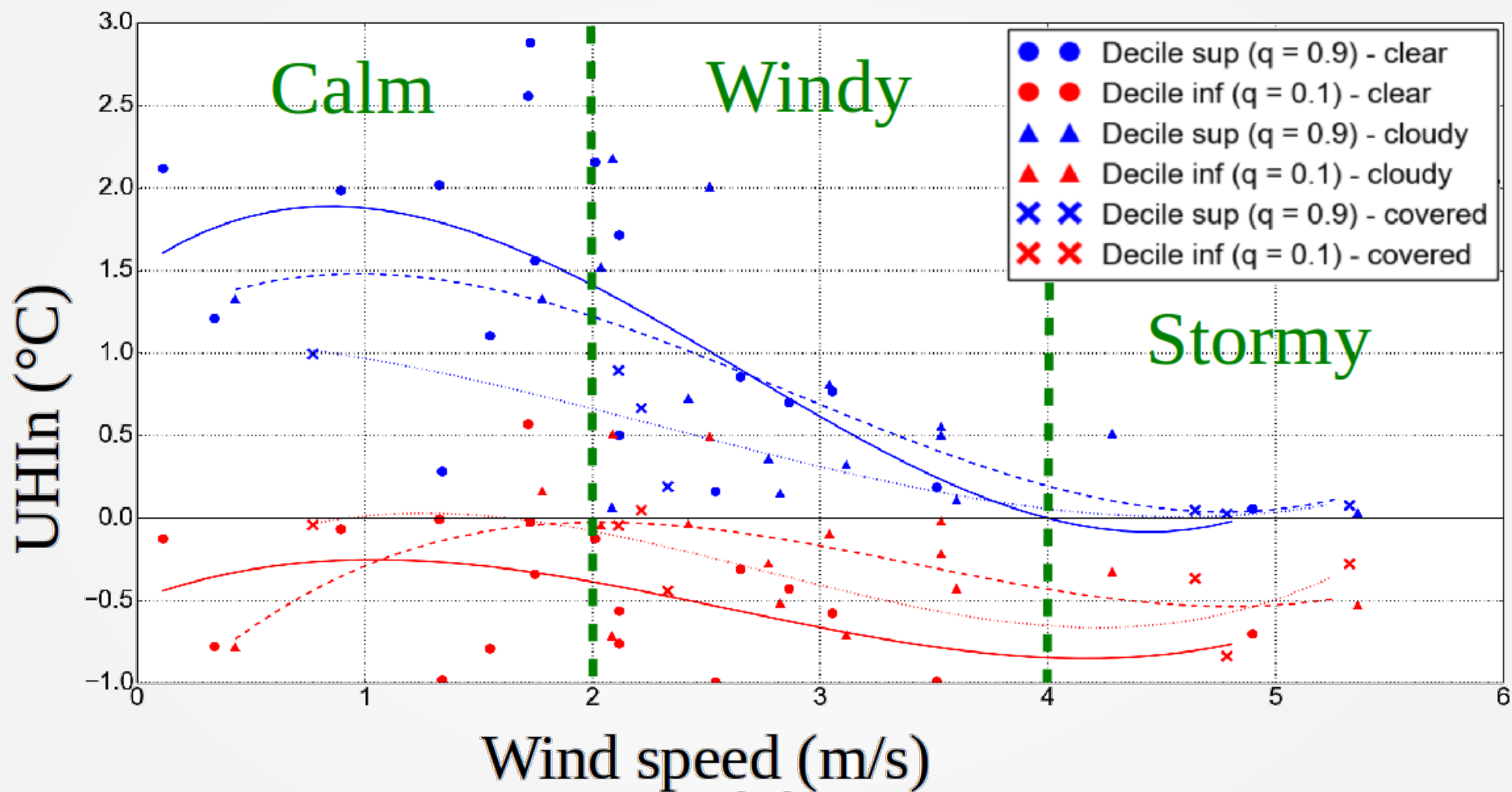
→ **Work supported by**

- French Environment and Energy Management Agency (ADEME)
- AgroCampus Ouest (ACO) school
- Region des Pays de la Loire

→ **Special thanks to :**

- OrbisGIS team for their technical support  
(<http://www.orbisgis.org/about/the-team/>)
- Meteo-France for the availability of their measurement data

# Wind speed classification





# Nebulosity classification

