Cross-analysis between variability of the urban climate and the landscape heterogeneity at the scale of a neighborhood

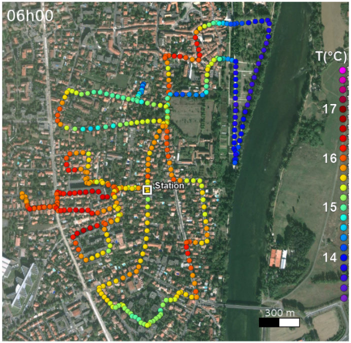
Julien Le Bras, Noémie Gaudio, Aude Lemonsu, Dominique Legain, Lina Quinteiro, Valéry Masson

Météo France / CNRS - Toulouse, France

9th International Conference on Urban Climate

Plan

Temperature variability measured with a bicycle in Blagnac the 3rd June 2009 in the morning



Source : projet PIRVE

$\Delta T=3°C$

Air temperature variability may have **the same magnitude** than the UHI

Objectives

Objectives

Cross-analysis of the temperature measured at the neighborhood scale with urban landscape heterogeneities

Objectives

Objectives

Cross-analysis of the temperature measured at the neighborhood scale with urban landscape heterogeneities

- **Step 1** : Experimental quantification of the spatial variability of urban microclimate at neighborhood scale

METEO FRANCE

Objectives

Objectives

Cross-analysis of the temperature measured at the neighborhood scale with urban landscape heterogeneities

- **Step 1** : Experimental quantification of the spatial variability of urban microclimate at neighborhood scale
- **Step 2** : Definition of urban landscape heterogeneities based on relevant indicators

Objectives

Objectives

Cross-analysis of the temperature measured at the neighborhood scale with urban landscape heterogeneities

- **Step 1** : Experimental quantification of the spatial variability of urban microclimate at neighborhood scale
- **Step 2** : Definition of urban landscape heterogeneities based on relevant indicators
- **Step 3** : Cross-analysis of temperatures and urban indicators

Objectives

Objectives

Cross-analysis of the temperature measured at the neighborhood scale with urban landscape heterogeneities

- **Step 1** : Experimental quantification of the spatial variability of urban microclimate at neighborhood scale
- **Step 2** : Definition of urban landscape heterogeneities based on relevant indicators
- **Step 3** : Cross-analysis of temperatures and urban indicators

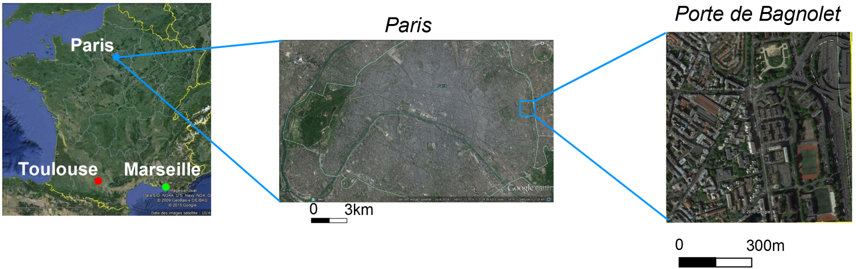
EUREQUA project (2012-2016) : Interdisciplinary project dealing with environmental quality of the districts

METEO FRANCE

Plan

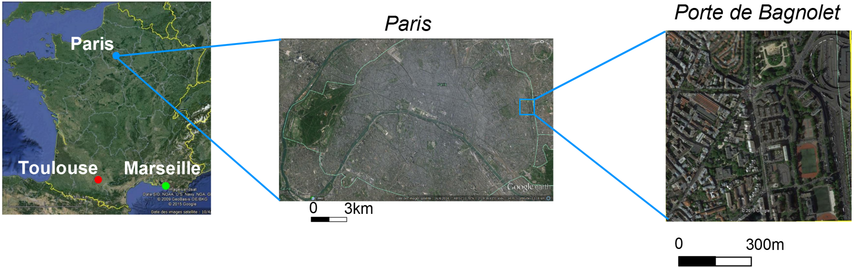
METEO FRANCE

Study areas



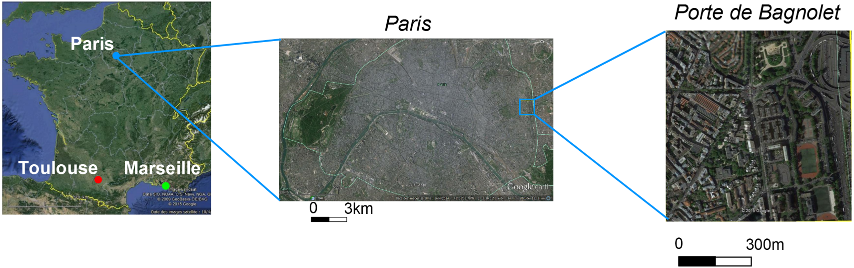
- Field campaign in Marseille (june 2013), Paris (october 2013), Toulouse (january to june 2014)

Study areas



- Field campaign in Marseille (june 2013), Paris (october 2013), Toulouse (january to june 2014)
- Study area : 500m by 500m

Study areas



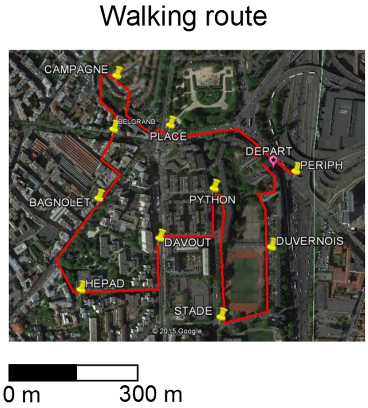
- Field campaign in Marseille (june 2013), Paris (october 2013), Toulouse (january to june 2014)
- Study area : 500m by 500m
- Strong heterogeneity of the urban landscape

METEO FRANCE

Instrumentation : mobile measurements

- Pedestrian mobile station
- Thin wire $\rightarrow$ high frequency measurements ($0.1s$)
- Reference station located on a roof in the neighborhood

Walking route



- Every 3 hours during 3 days
- Length : 2,9km Duration : 1 hour
- 10 stop points in various urban fabrics

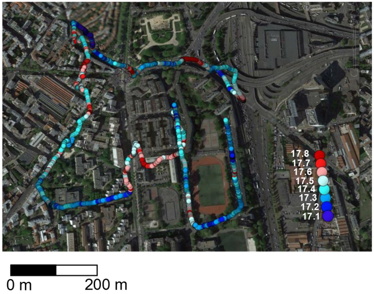
Treatment of the temperature data

Step 1 : Correction of the temperature signal

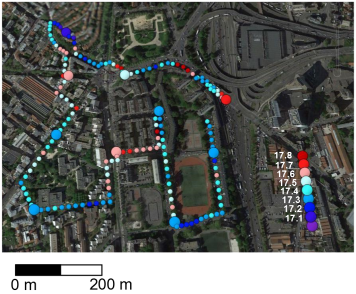
Treatment of the temperature data

Step 1 : Correction of the temperature signal
Step 2 : Projection on an ideal route

Temperature with a raw GPS recording

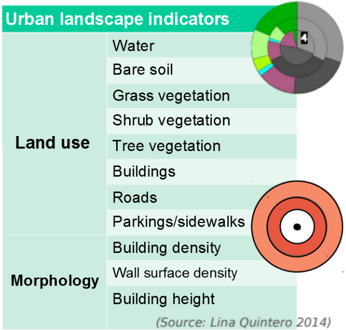


Temperature with a corrected GPS recording



Plan

Data describing the urban landscape

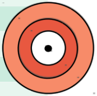


Urban landscape indicators	
Land use	Water
	Bare soil
	Grass vegetation
	Shrub vegetation
	Tree vegetation
	Buildings
	Roads
	Parkings/sidewalks
Morphology	Building density
	Wall surface density
	Building height

(Source: Lina Quintero 2014)

Data describing the urban landscape

Urban landscape indicators	
Land use	Water
	Bare soil
	Grass vegetation
	Shrub vegetation
	Tree vegetation
	Buildings
	Roads
	Parkings/sidewalks
Morphology	Building density
	Wall surface density
	Building height

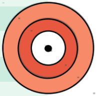


(Source: Lina Quintero 2014)

- 11 urban parameters chosen

Data describing the urban landscape

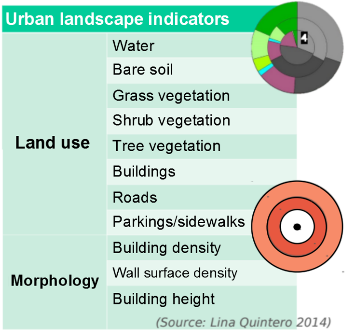
Urban landscape indicators	
Land use	Water
	Bare soil
	Grass vegetation
	Shrub vegetation
	Tree vegetation
	Buildings
	Roads
	Parkings/sidewalks
Morphology	Building density
	Wall surface density
	Building height



(Source: Lina Quintero 2014)

- 11 urban parameters chosen
- Manual mapping with GIS

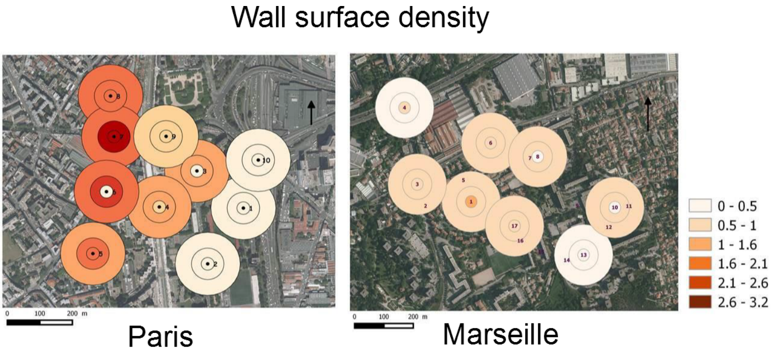
Data describing the urban landscape



- 11 urban parameters chosen
- Manual mapping with GIS
- Aggregation in buffers with a radius of 10m to 100m

Example of the variability of the wall surface density

Wall surface density :Total wall surface of buildings intersected in a reference zone divided by the total surface of the reference zone (m^2/m^2)



Plan

Cross-analysis of the temperature with the urban indicators

Objectives

To establish an **unique** statistical relation, valid for every cities and every seasons.

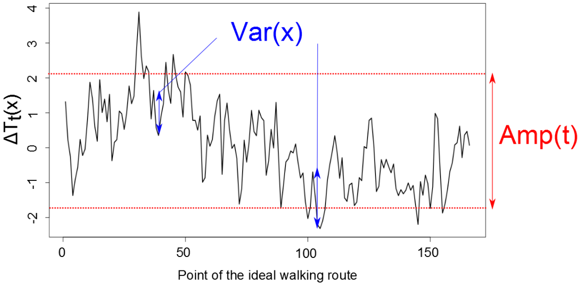
Cross-analysis of the temperature with the urban indicators

Objectives

To establish an **unique** statistical relation, valid for every cities and every seasons.

Hypothesis

$$\Delta T_t(x) = Amp(t) \times Var(x)$$



Relation between amplitude and weather conditions

- Test for many parameters : temperature, humidity, wind, shortwave and longwave radiation, 12 hours integrated radiation, cloud cover
- Test on **every campaigns** for every cities

METEO FRANCE

Relation between amplitude and weather conditions

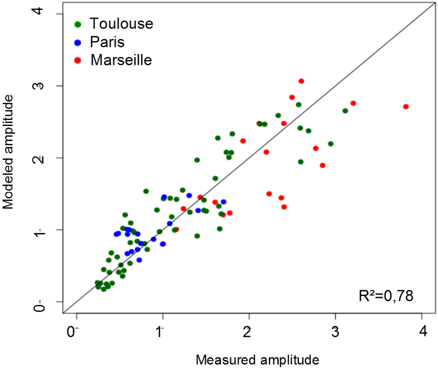
- Test for many parameters : temperature, humidity, wind, shortwave and longwave radiation, 12 hours integrated radiation, cloud cover
- Test on **every campaigns** for every cities

Results with a multiple linear regression

$$Amp(t) = 0{,}58 + 0{,}0015\ Ray + 0{,}053\ T - 0{,}16\ V_S - 0{,}041\ Couv$$

Relation between amplitude and weather conditions

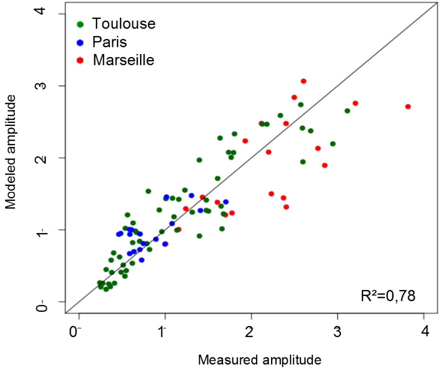
$$Amp(t) = 0{,}58 + 0{,}0015\ Ray + 0{,}053\ T - 0{,}16\ V_S - 0{,}041\ Couv$$



→ Hypothesis on the amplitude validated

Relation between amplitude and weather conditions

$$Amp(t) = 0{,}58 + 0{,}0015\ Ray + 0{,}053\ T - 0{,}16\ V_S - 0{,}041\ Couv$$

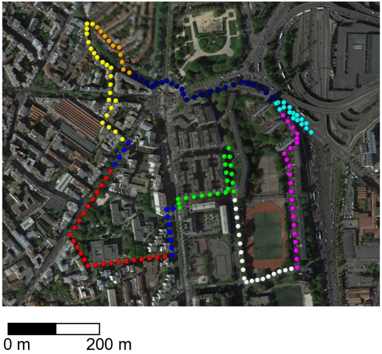


→ Hypothesis on the amplitude validated

METEO FRANCE

Local zones

Noisy measurements $\rightarrow$ division in 9 zones



- Cité Python (PYTH)
- Stade (STAD)
- Rue Veber (VEBE)
- Grands boulevards (GRDB)
- EHPAD (EHPA)
- Rue de la Py (RUPY)
- Campagne à Paris (CAMP)
- Porte de Bagnolet (BAGN)
- Périphérique (PERI)

Local zones

Noisy measurements → division in 9 zones

METEO FRANCE

Evaluation of the parameter $Var(x)$

1. Determination of the influence radius of each urban indicator

Evaluation of the parameter $Var(x)$

1. Determination of the influence radius of each urban indicator
2. Multiple linear regression for each city, day and night with urban indicators with their associated influence radius as explanatory variables

Evaluation of the parameter $Var(x)$

1. Determination of the influence radius of each urban indicator
2. Multiple linear regression for each city, day and night with urban indicators with their associated influence radius as explanatory variables

Example for Paris

$$\begin{cases} Var(x) = -0,051 Shrub_{40} - 0,032 Grass_{40} - 0,022 BareSo_{40} + 0,037 & (R^2 = 0,92)\ day \\ Var(x) = 0,013 Road_{60} + 0,060 Bd_{40} + 0,023 Tree_{70} + 0,038 & (R^2 = 0,90)\ night \end{cases}$$

Evaluation of the hypothesis

$$\Delta T_t(x) = Amp(t) \times Var(x)$$

Town	Model	R^2
Marseille	Marseille	**0,68**
	Global	0,29
Paris	Paris	**0,45**
	Global	0,37
Toulouse January	Toulouse 01	0,12
	Global	0,10
Toulouse April	Toulouse 04	0,14
	Global	0,06
Toulouse June	Toulouse 06	0,14
	Global	0,02

METEO FRANCE

Evaluation of the hypothesis

$$\Delta T_t(x) = Amp(t) \times Var(x)$$

Town	Model	R^2	
Marseille	Marseille	**0,68**	**High variability of high vegetation**
	Global	0,29	
Paris	Paris	**0,45**	**High variability of built density**
	Global	0,37	
Toulouse January	Toulouse 01	0,12	**Low variability of built density or high vegetation**
	Global	0,10	
Toulouse April	Toulouse 04	0,14	
	Global	0,06	
Toulouse June	Toulouse 06	0,14	
	Global	0,02	

→ no global relation !

Plan

Conclusion

Conclusion

- Hypothesis $\Delta T_t(x) = Amp(t) \times Var(x)$ correct
- Amplitude linked to weather parameters
- No global statistical relation for every seasons or every cities

METEO FRANCE

Conclusion

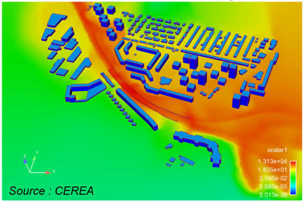
Conclusion

- Hypothesis $\Delta T_t(x) = Amp(t) \times Var(x)$ correct
- Amplitude linked to weather parameters
- No global statistical relation for every seasons or every cities

Perspectives

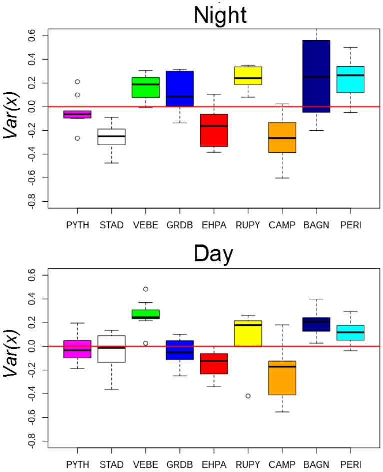
- Comparison to a CFD model

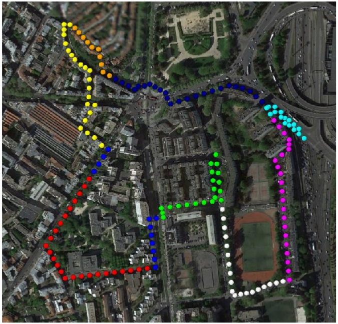
Pollutants field on the tolosan neighborhood



METEO FRANCE

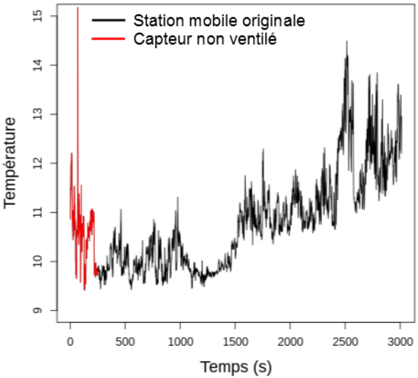
Normalized temperature variability $Var(x)$ by zones



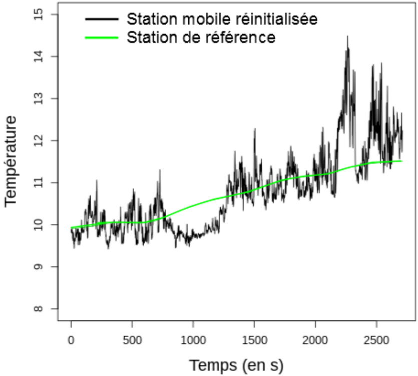


- Difference day/night(STAD,GRDB)
- Vegetated zones are fresh (STAD,EHPA,CAMP)
- Dense zones or with traffic are hot (VEBE, RUPY, BAGN, PERI)

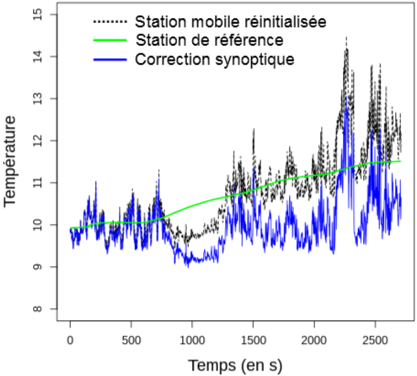
Correction of the temperature signal



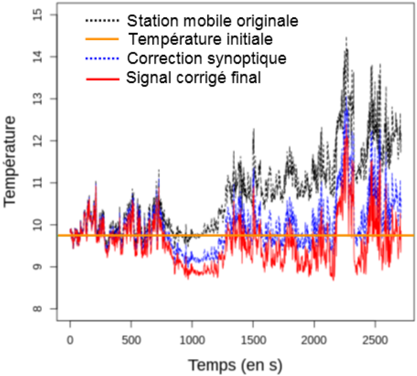
Correction of the temperature signal



Correction of the temperature signal

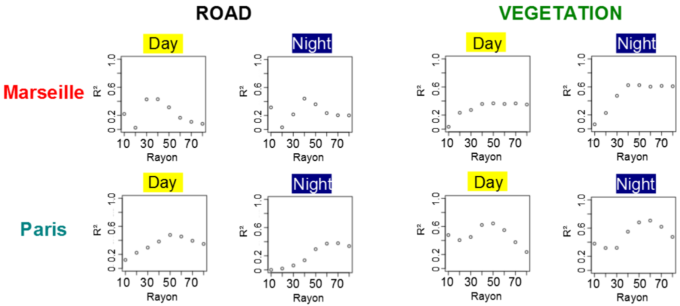


Correction of the temperature signal



Influence radius

For each city and each parameter, the coefficient R^2 coming from a linear regression between temperature variability and the variability of the parameter in a radius is calculated.



Seasons in Toulouse