Watering practices and urban thermal comfort improvement under heat wave conditions

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ICUC9 - CCMA7: UHI mitigation strategies III : watering processes studies

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Objective : mitigate the Urban Heat Island (UHI)

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- Create reactive cities to face heat-wave events

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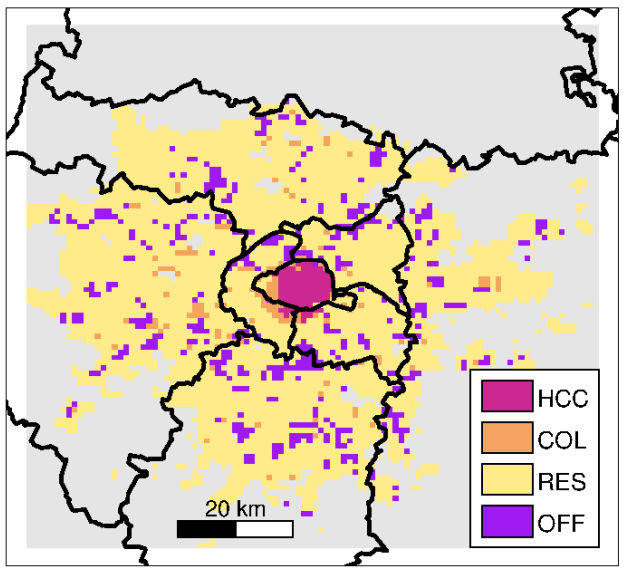
- Create reactive cities to face heat-wave events
- Improve population thermal comfort
- *Implementation of vegetation in the city*
- *What type of vegetation ?* **What irrigation must be used ?**

Modeling set-up

Urban expansion modeling : NEDUM-2D (Viguié et al., 2014)

- Socio-economic model : macro-economic trends
  Population density, housing surfaces,...
- "Business as usual" simulation until 2100



Spatial expansion and building typologies of the city of Paris in 2100

Urban climate modeling

SURFEX model

- 1km horizontal resolution over the Parisian Basin.
- Oflline simulation
- 7 days close to 2003 heat-wave. Intensity 38 °C
- Urban model : TEB (Masson, 2000)

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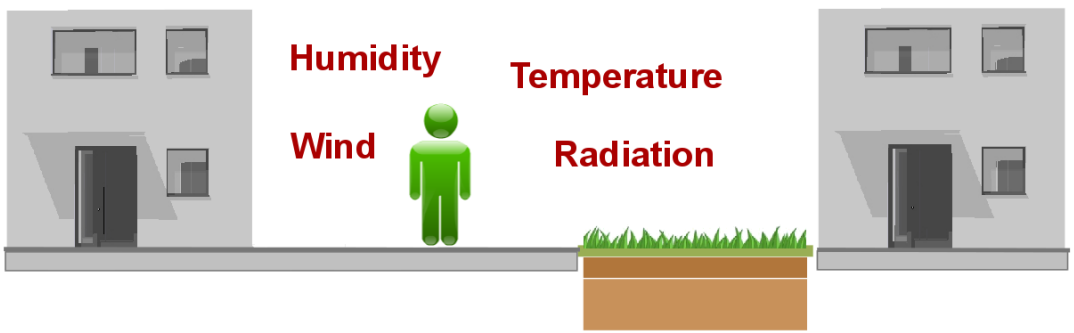

- 2m-Temperature
- Outdoor UTCI

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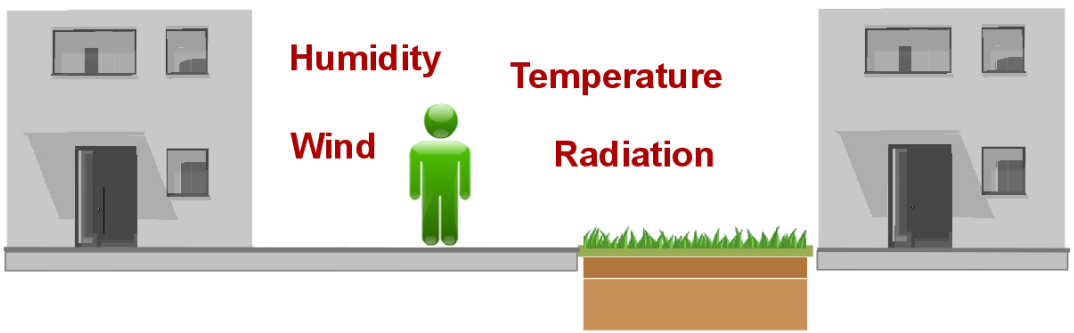

- 2m-Temperature
- Outdoor UTCI
- *Trees shadow not computed*
- *Basic underground hydrology*

Plant irrigation scenarios

- **No irrigation**
  No water supply

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- **Unrestricted** irrigation
  No hydric stress for vegetation
  Unrealistic but **usually used**

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- **Realistic** irrigation
  Frequency : 8h of irrigation from 11pm to 7am
  Rate : $3.50 L/m^2/day$

Pavement watering scenario

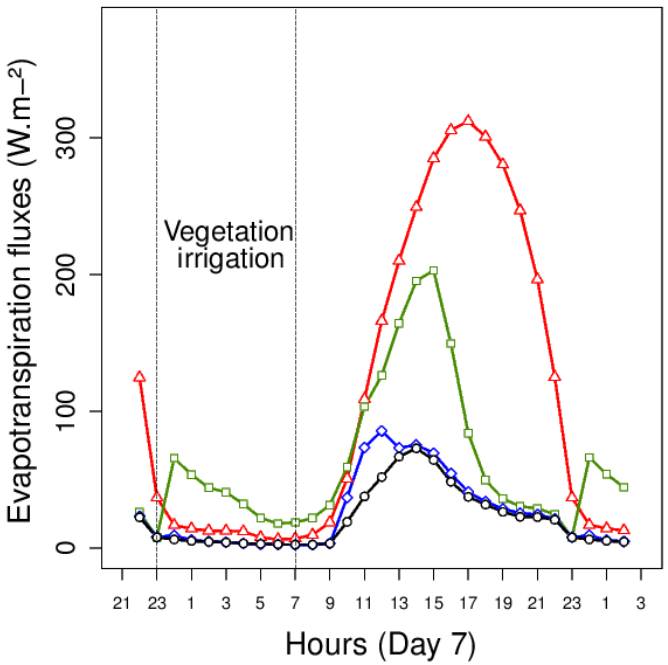
- Motivated by Takahashi et al. work (2010)
- Based on the sensitivity analysis of EPICEA (Kounkou et al., 2014)

Pavement watering

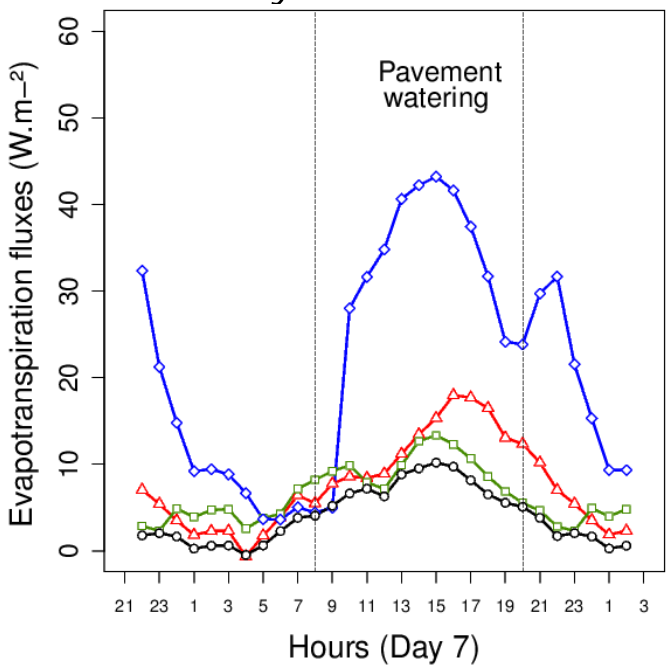
- Frequency : 3min per hour
- Rate : $2.80 L/m^2/day$

Evapotranspiration

Suburbs

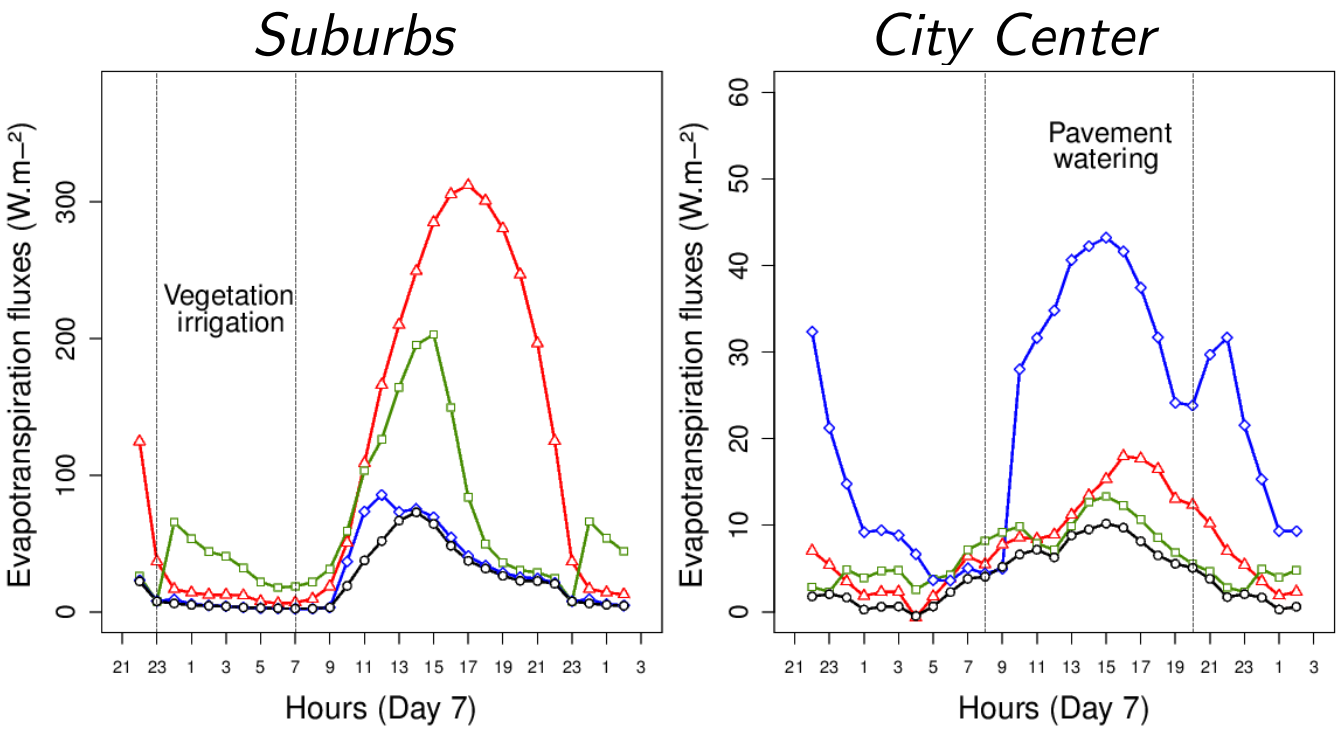


City Center



- Unrestricted
- Realistic
- Pavement
- No Irrigation

Evapotranspiration



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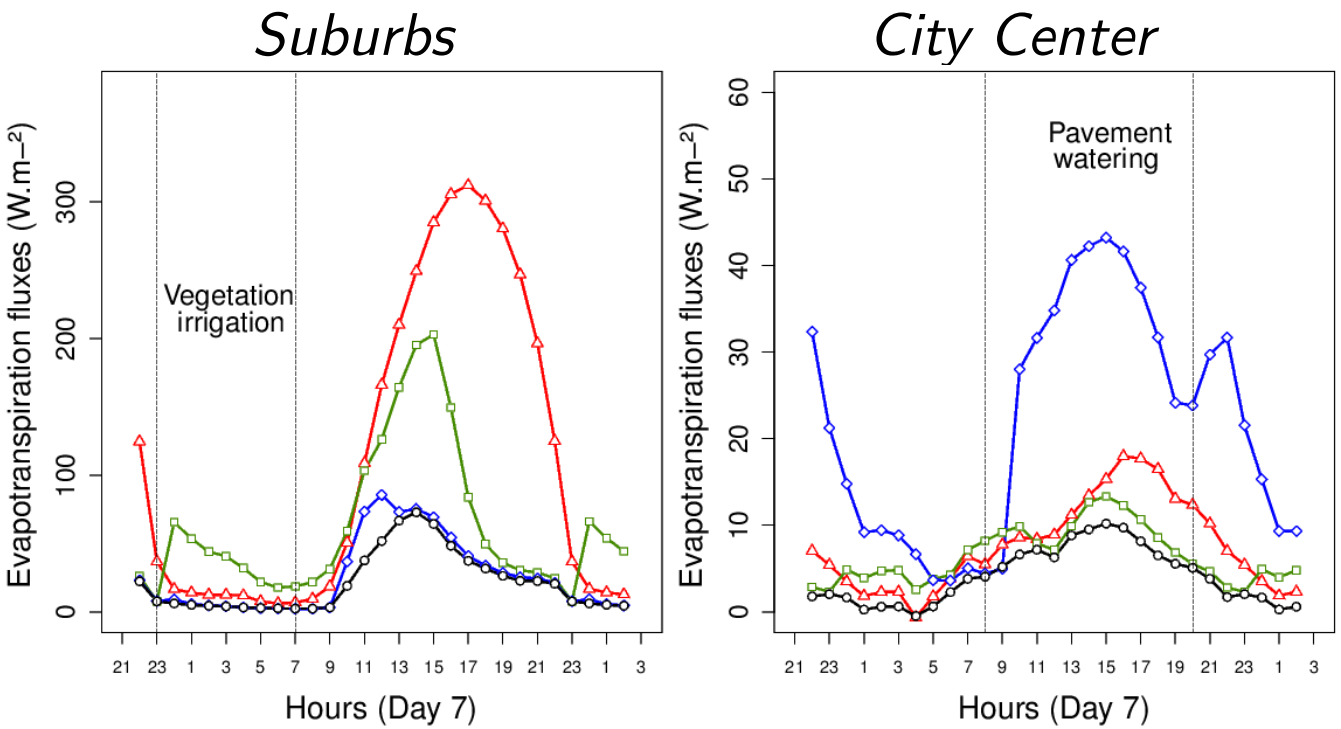
- **Suburbs** : vegetation irrigation

Evapotranspiration



- Unrestricted
- Realistic
- Pavement
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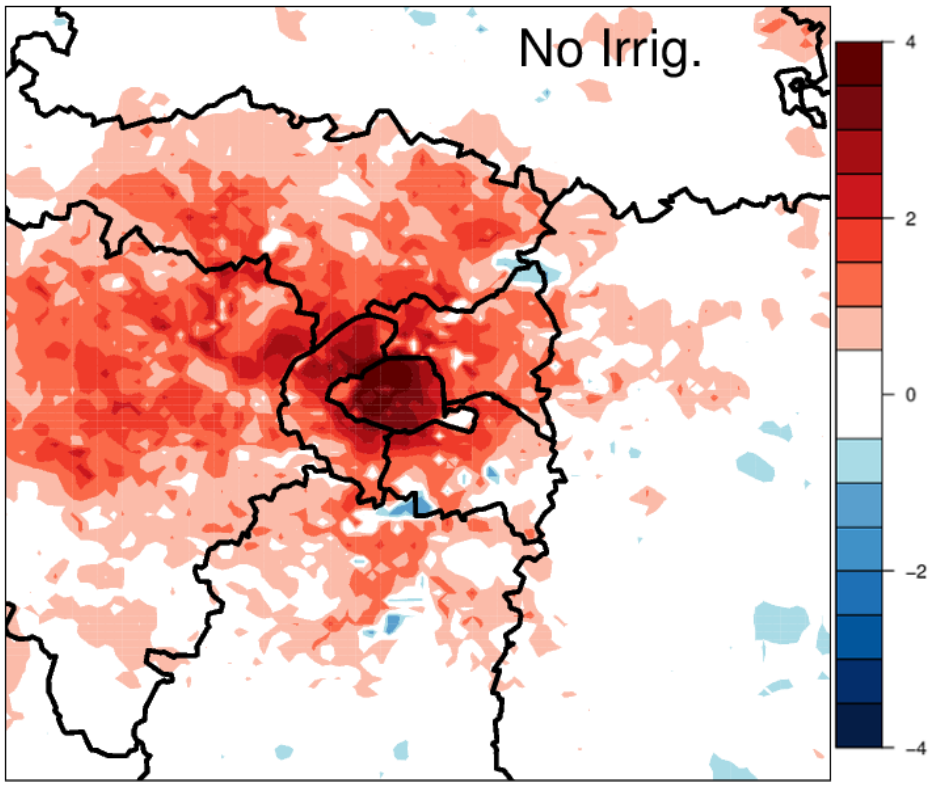
- **Suburbs** : vegetation irrigation
- **City center** : pavement watering

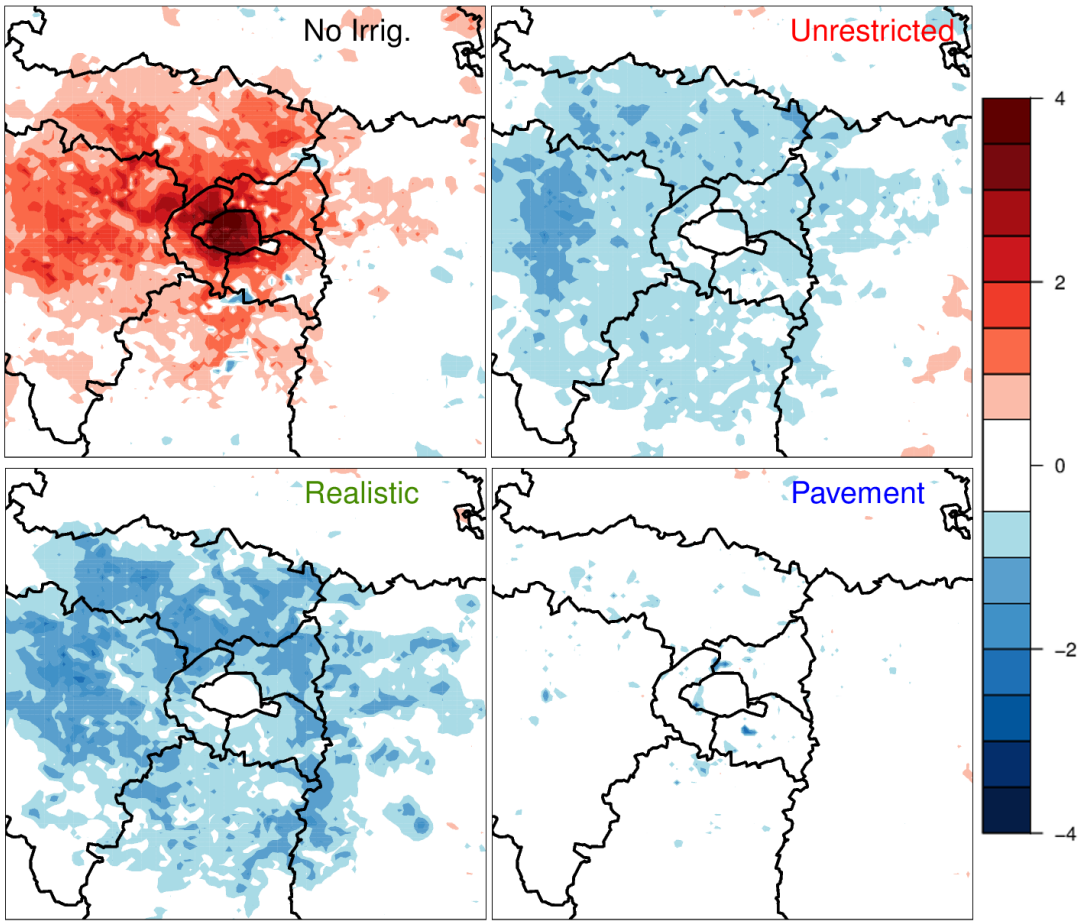
Urban Heat Island : Night



Spatial representation of the UHI during nighttime hours

- Large UHI
- Intensity : 3.5 °C in city center

Urban Heat Island : Night

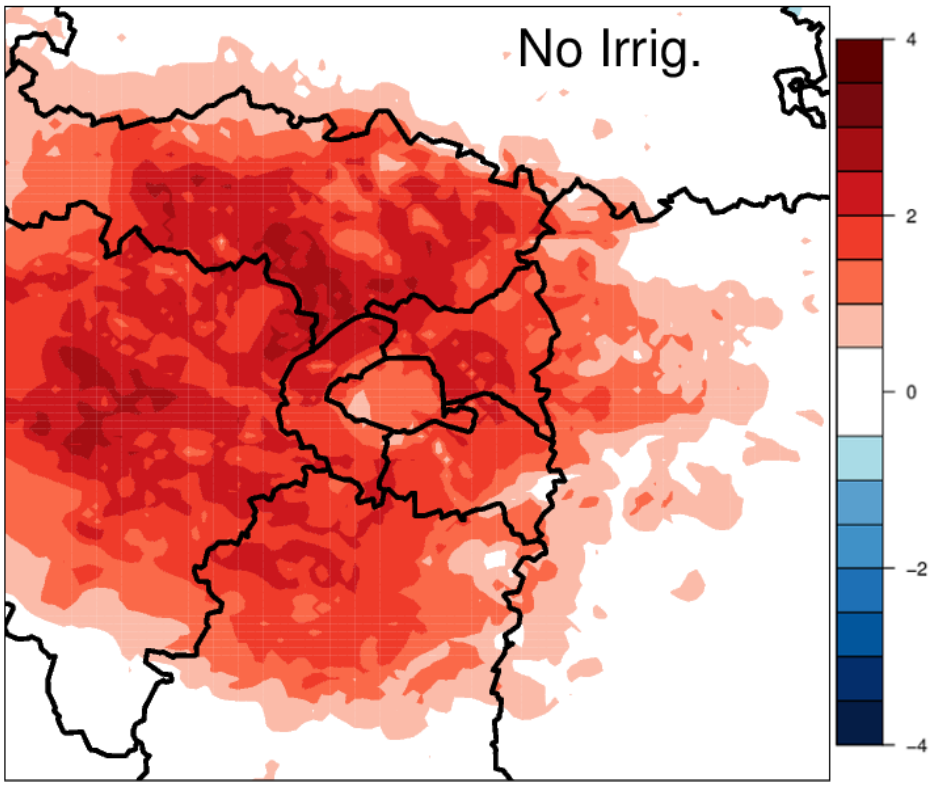


2m-Temperature : Differences No Irrigation vs Irrigated scenarios

Unrestricted/Realistic :
No effect in city center
-2 °C in suburbs

Pavement :
No improvement

Urban Heat Island : Day



Spatial representation of the UHI during daytime hours

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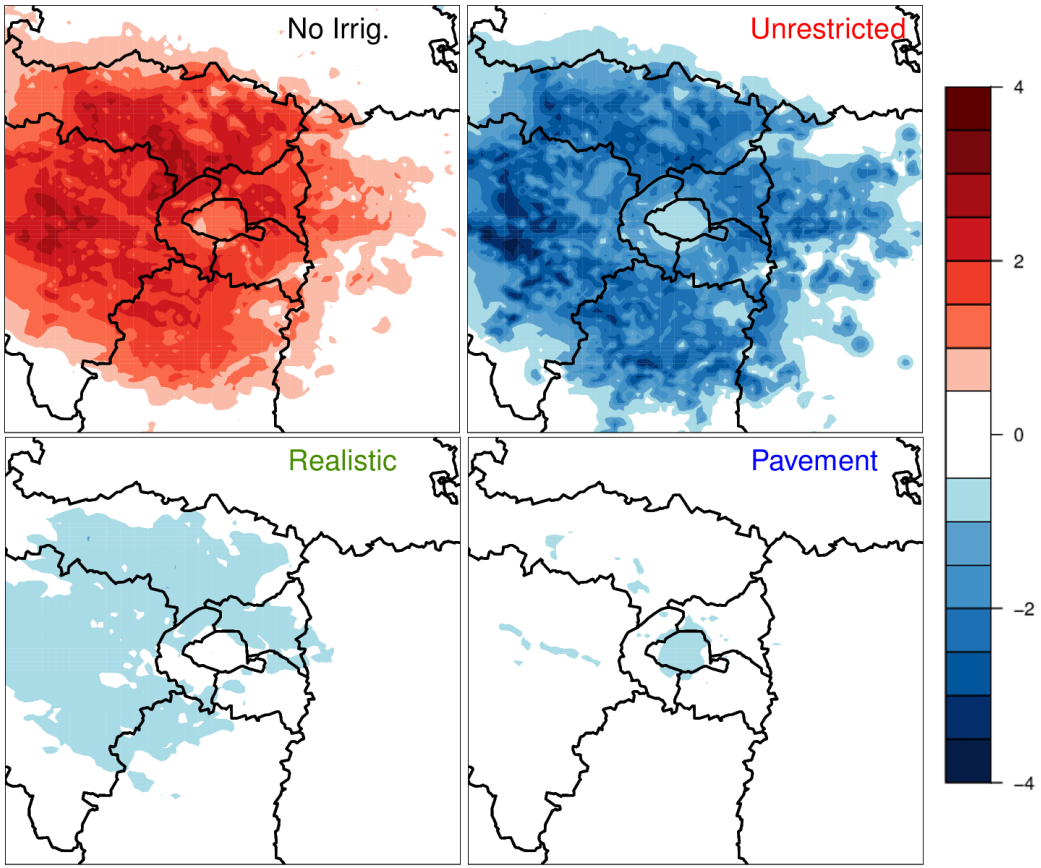


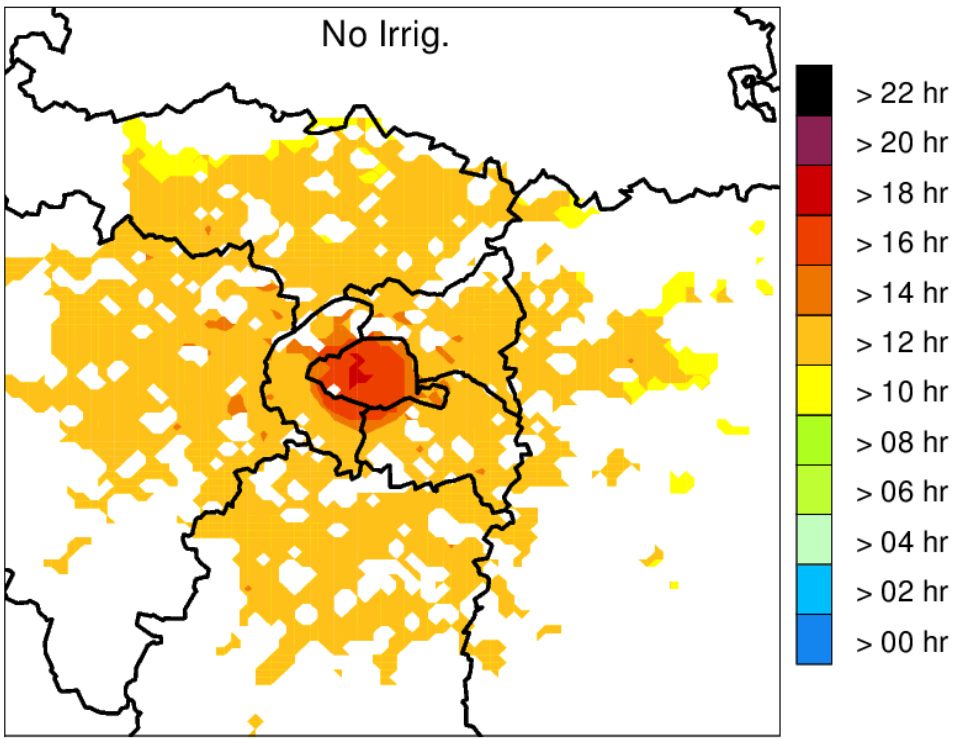
2m-Temperature : Differences No Irrigation vs Irrigated scenarios

Unrestricted :
-3 °C in suburbs

Realistic :
-1 °C in **suburbs**

Pavement :
-1 °C in **city center**

Outdoor Thermal Comfort : UTCI>32 °C



Spatial distribution of outdoor strong heat stress conditions for day 7

- 12h in Strong Heat Stress
- Up to 18h in City Center

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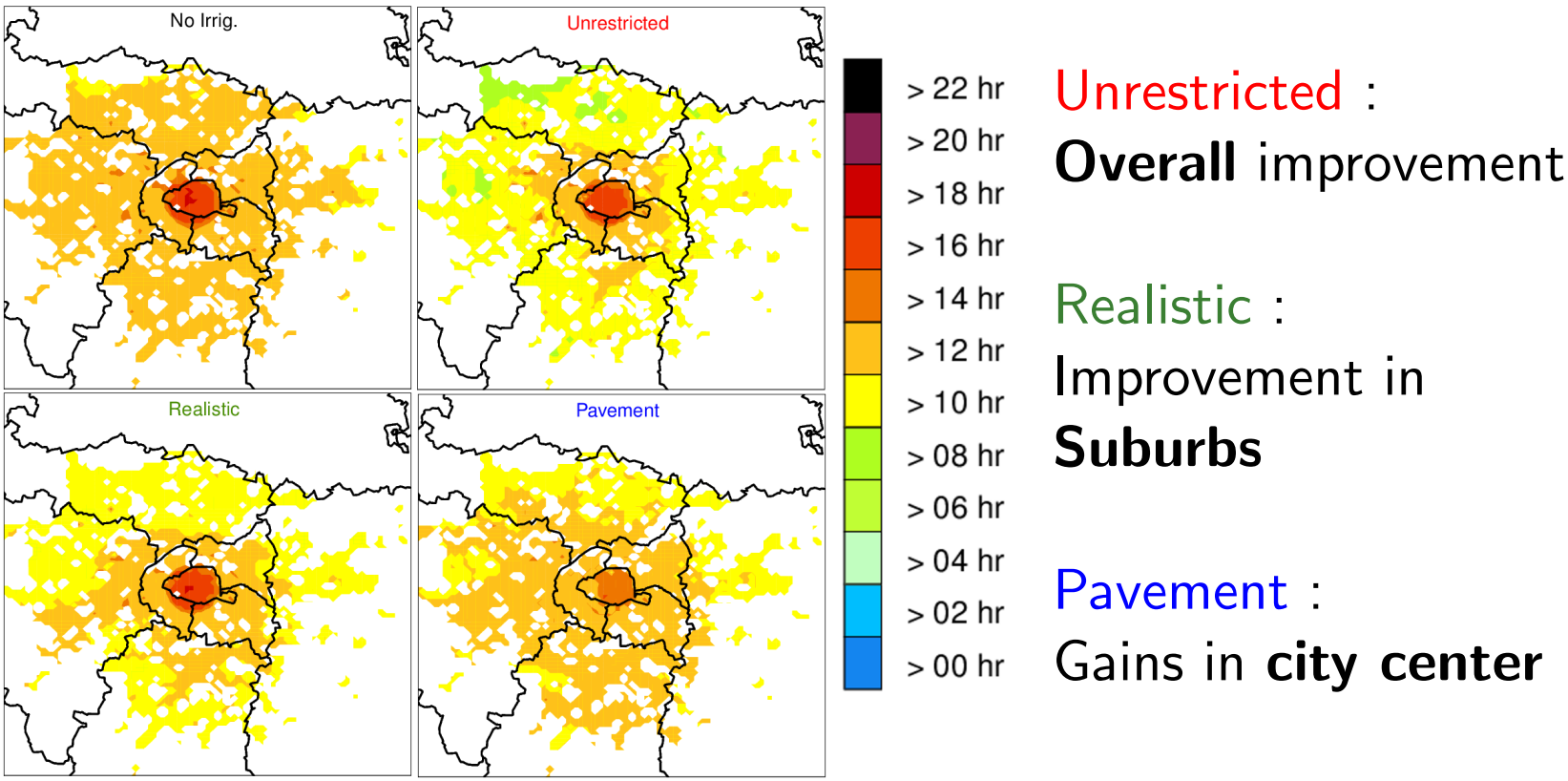


Spatial distribution of outdoor strong heat stress conditions for day 7

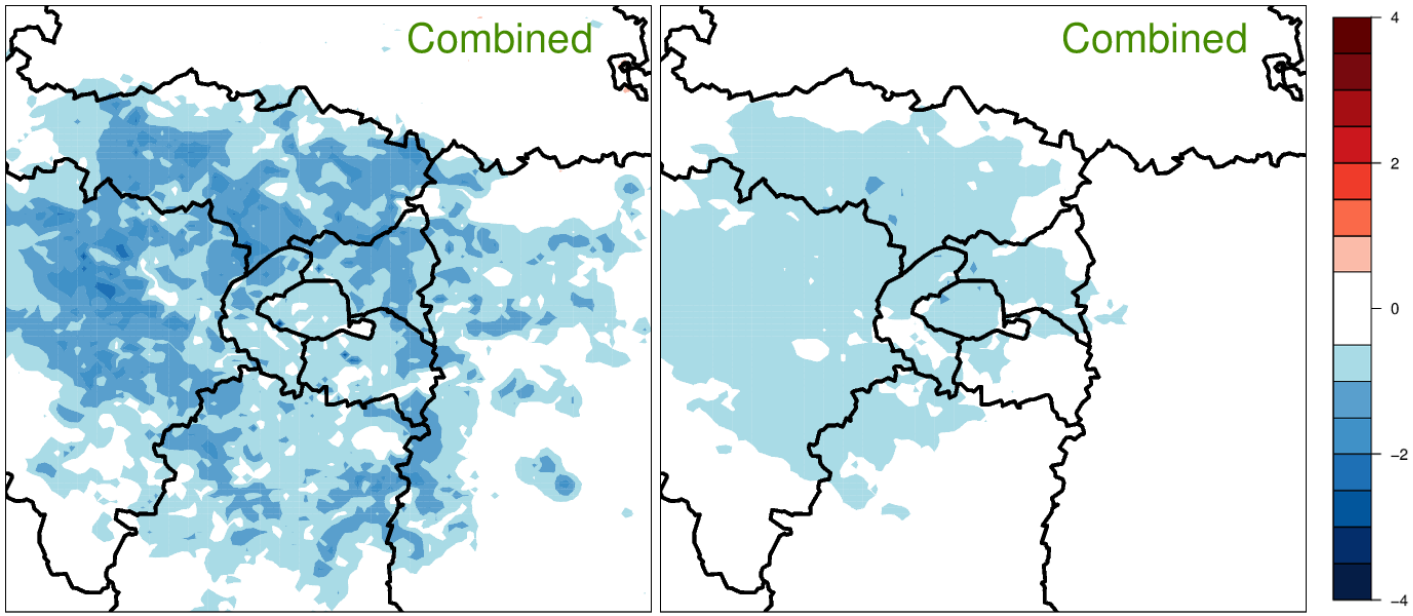
Unrestricted :
Overall improvement

Realistic :
Improvement in
Suburbs

Pavement :
Gains in **city center**

Combined scenario : Realistic + Pavement in City Center

Night *Day*

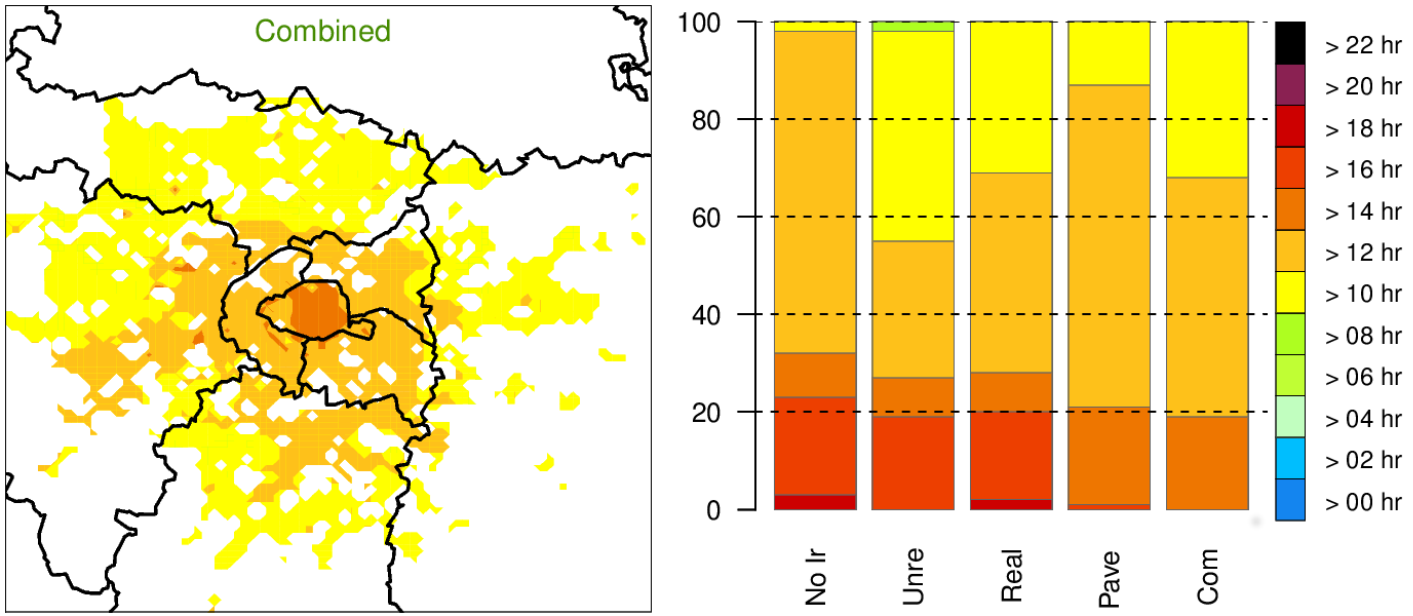


2m-Temperature : Differences No Irrigation vs Combined scenarios

Benefits from
Realistic

Benefits from :
Realistic in suburbs
Pavement in city center

Combined scenario : Realistic + Pavement in City Center



Distributions of outdoor strong heat stress conditions for day 7

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Realistic irrigation in suburbs

Pavement watering in city center

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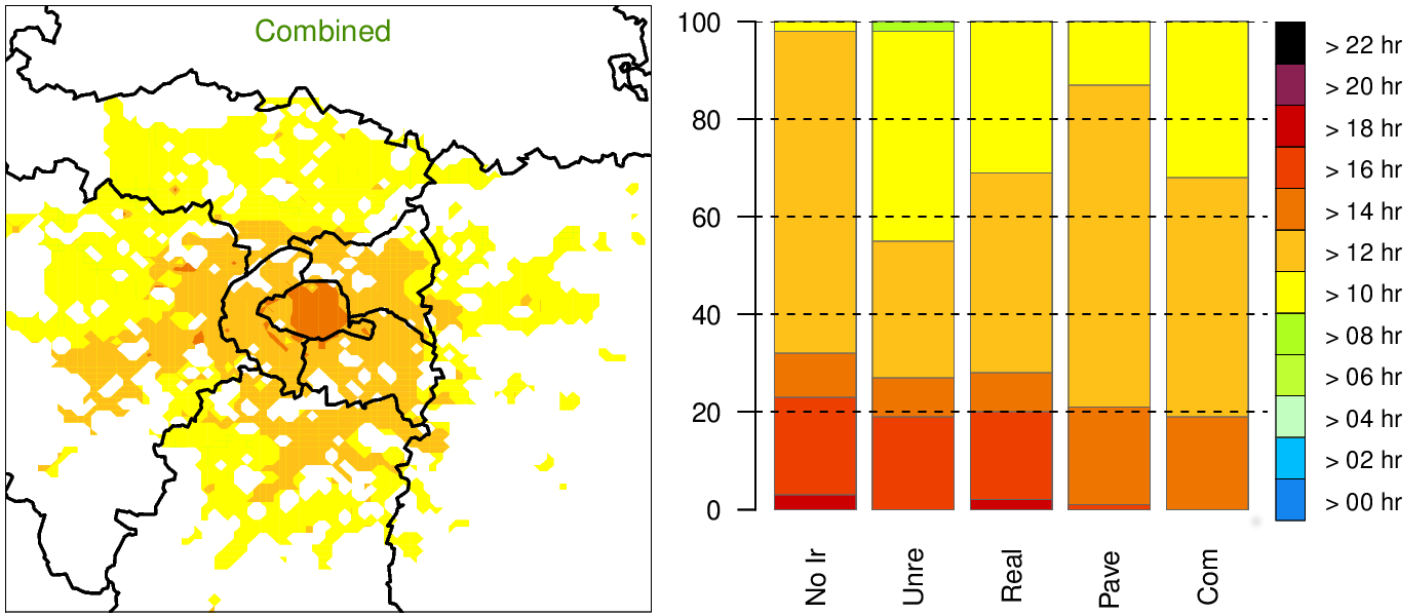

Distributions of outdoor strong heat stress conditions for day 7

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Almost no extra water supply needed

Water consumption

Water demand	Unrestricted	Realistic	Pavement	Combined
$10^6 m^3/day$	**5.5**	**4.9**	1.5	**5.0**
% Seine	18.7	17.3	5.1	17.5
% 2100 Seine	26.7	24.6	7.3	25.0

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- Vegetation location should be considered
- Depends on city shapes

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- Water storage in summer conditions ?

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- Water storage in summer conditions ?
- What type of vegetation to be used ?

Any Questions ?

References

Viguié et al. 2014, *Technological Forecasting and Social Change*
Masson 2000, *Boundary-Layer Meteorology*
Takahashi et al. 2010, *Sustainable techniques and strategies in urban water management*
Kounkou et al. 2014, *Météorologie (in French)*