Influence des arbres de rue dans le modèle de micro-climat urbain TEB

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Plan

I Land surface modeling

II Application to urban mixed environments

III How urban vegetation is represented in TEB model ?

IV Testing several adaptative strategies, example of Paris city

V Ongoing implementations in TEB Veg

VI Conclusion

I Land surface modeling

SURFEX platform

Seas and oceans | Natural soils and vegetation | Lakes and rivers | Cities

Mesoscale to microscale atm modeling

Weather forecasting

Surface processes

Climate

Hydrology

I Land surface modeling

SURFEX platform

Seas and oceans | Natural soils and vegetation | Lakes and rivers | Cities

Land surface defined as a mosaic of different types of cover with specific parameterizations

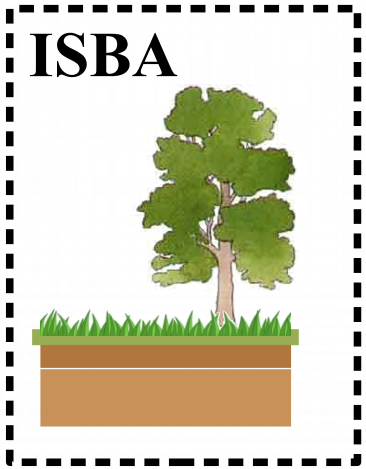
Energy, water, and momentum fluxes calculated for each type of cover and aggregated at the grid mesh scale

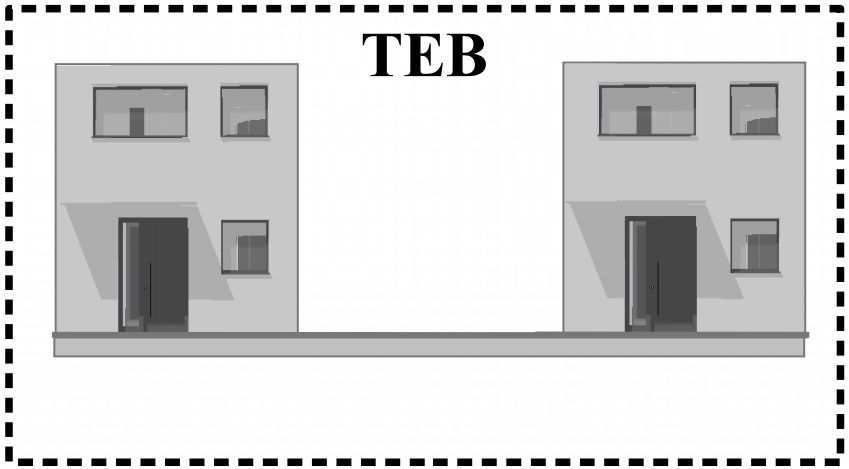
From Lemonsu, ICUC8 2012

II Application to urban mixed environments

SURFEX platform

Seas and oceans | Natural soils and vegetation | Lakes and rivers | Cities





From Lemonsu, ICUC8 2012

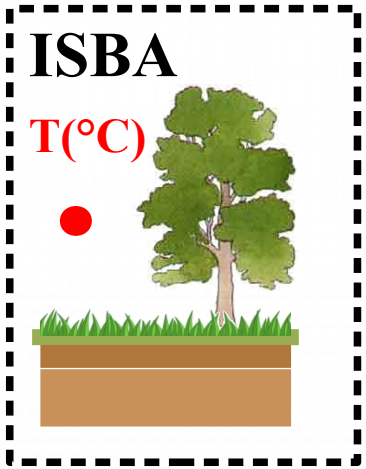
II Application to urban mixed environments

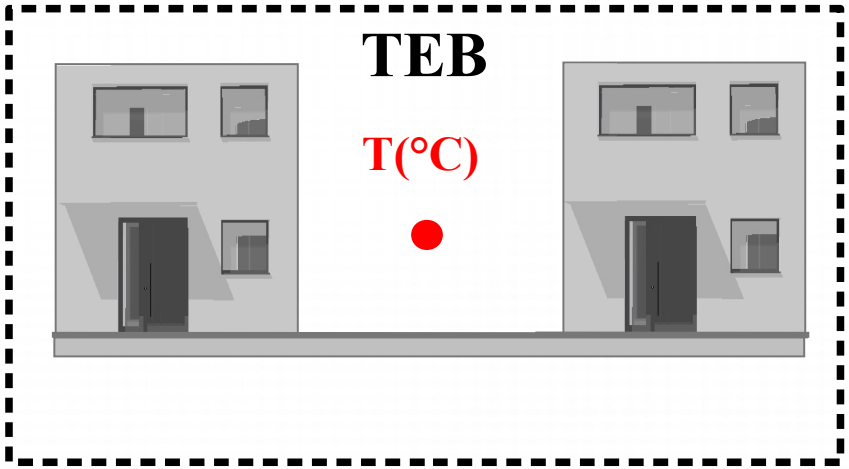
No interaction inside the canopy between artificial surfaces and vegetation

ISBA : Soil-Biosphere-Atmosphere Interaction, a SVAT model

TEB : Town Energy Balance, a urban canopy model

2-m air temperature calculated as the average of T2m from each model





From Lemonsu, ICUC8 2012

II Application to urban mixed environments

OBJECTIVES

Weather forecasting at fine scale

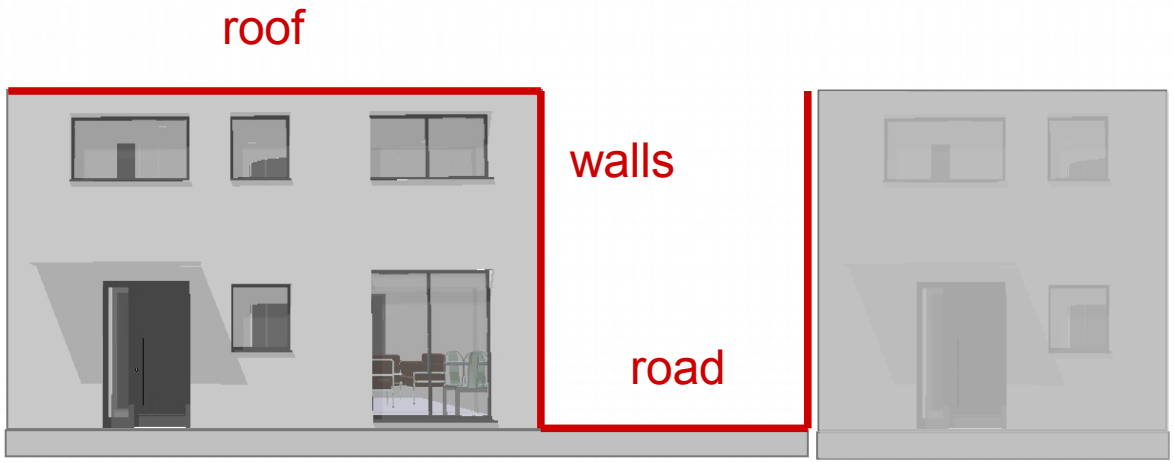
Mitigation of UHI : urban planning strategies assessment

Cooling power of greening strategies ? Associated water resources ? Thermal comfort of inhabitants ?

+ public parks
+ private gardens
+ street trees
+ greenroofs, green walls
+ soil, subsoil, sewer network
+watering

III How urban vegetation is represented in TEB model ?

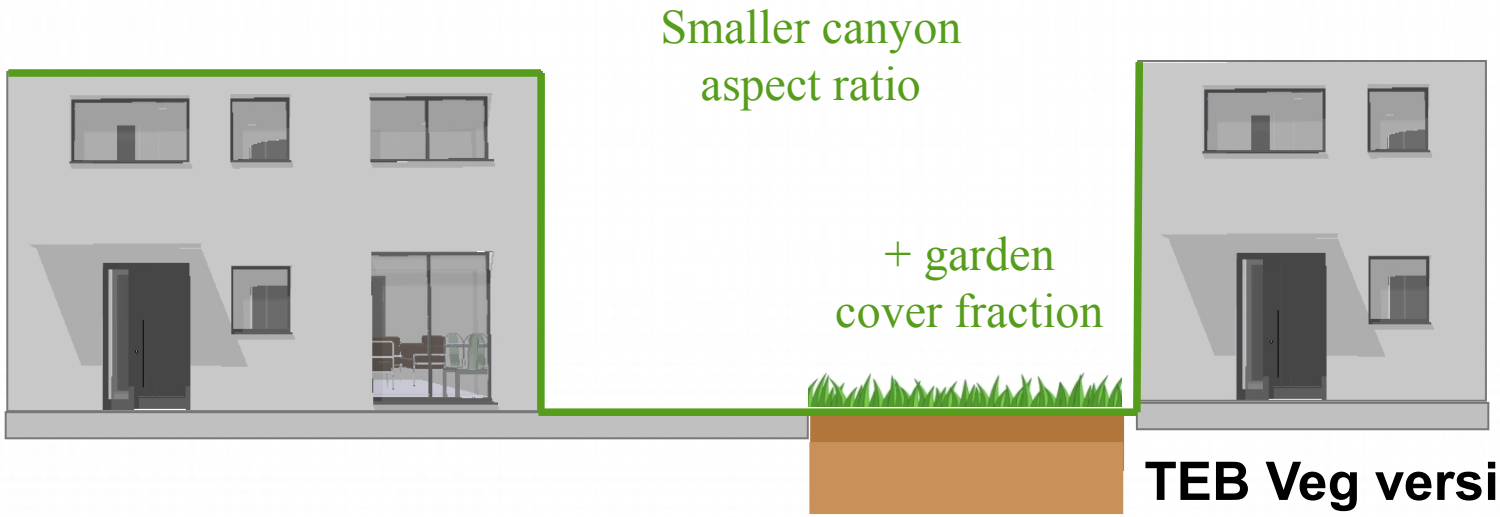
Radiative and energy budget / surface



original TEB
(Masson, 2000)

III How urban vegetation is represented in TEB model ?

1. Definition of geometric parameters accounting for gardens
2. Integration of gardens inside the urban canyon (as a cover fraction)



TEB Veg version
Lemonsu *et al.*, 2012

III How urban vegetation is represented in TEB model ?

Focus on ISBA : a detailed **S**oil **V**egetation **A**tmosphere **T**ransfer model

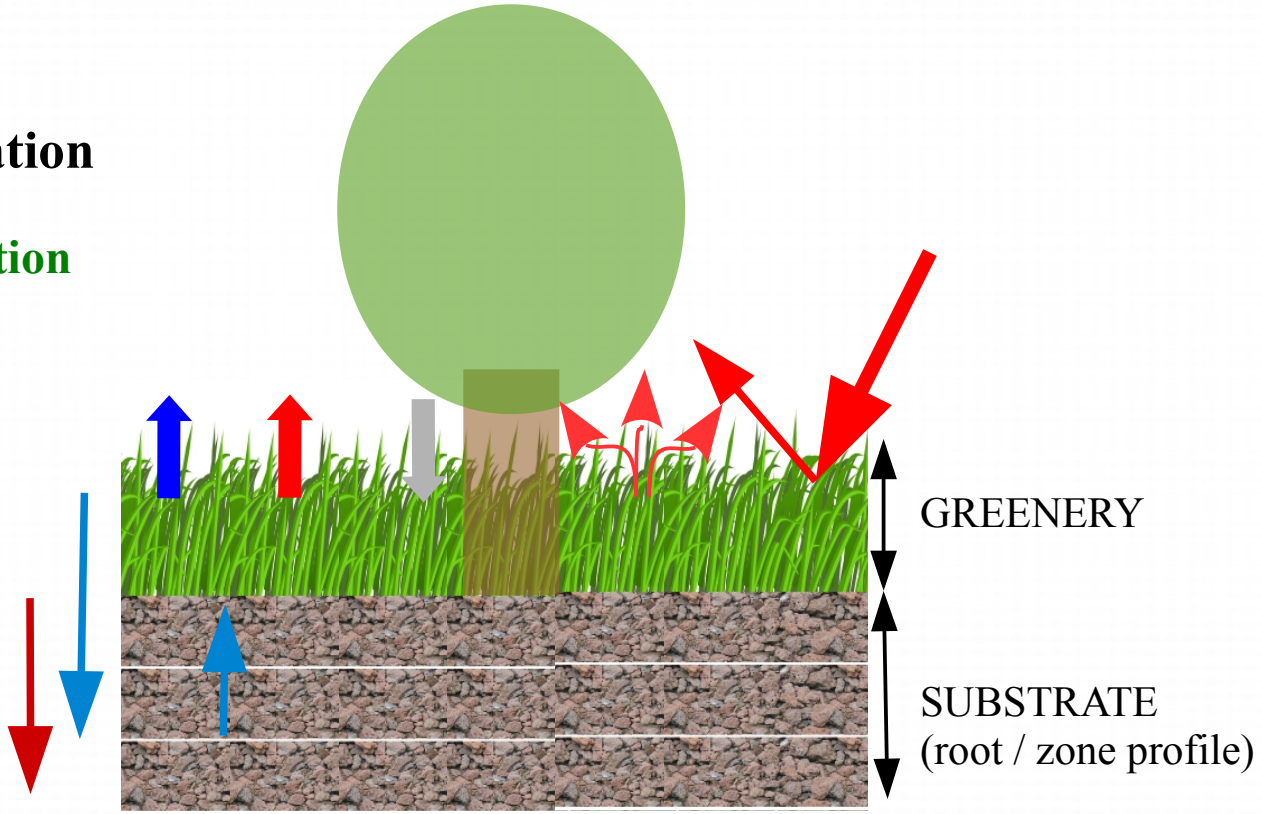
Radiative budget : Direct and diffuse solar radiation + IR radiation
Energy budget : **Le : latent heat flux** **H : sensible heat flux** **G : ground / storage heat flux**
Thermal conduction
Hydrological processes
Vegetation characterization

High / low vegetation fraction

↓

Physiological parameters (stomatal conductance...)

Root zone depth
Leaf Area Index
Roughness length
Albedo
...



III How urban vegetation is represented in TEB model ?

1. Definition of geometric parameters accounting for gardens
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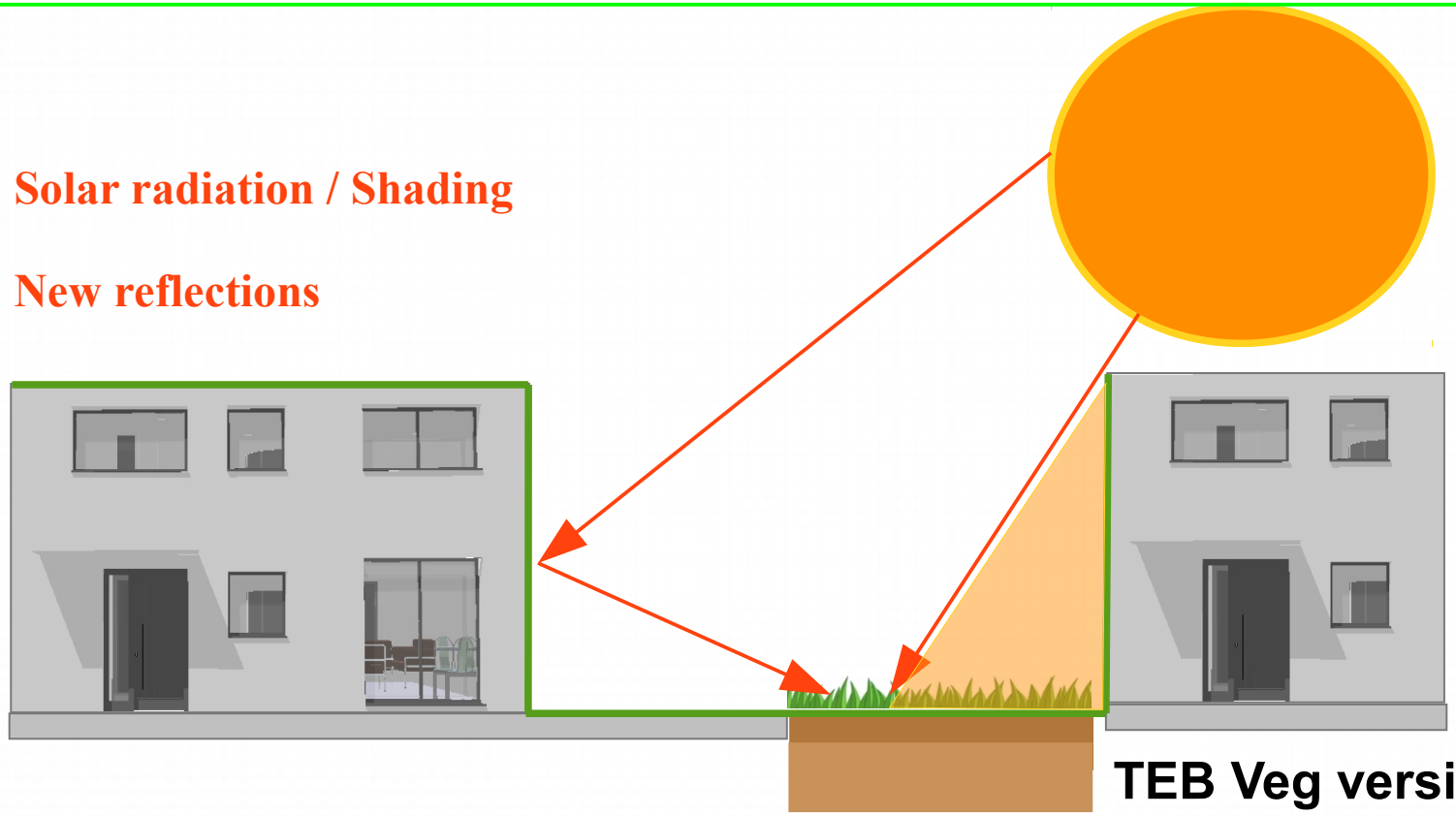
3. **New radiative budget including shadow effects, new reflections**

Solar radiation / Shading

New reflections



TEB Veg version
Lemonsu *et al.*, 2012

III How urban vegetation is represented in TEB model ?

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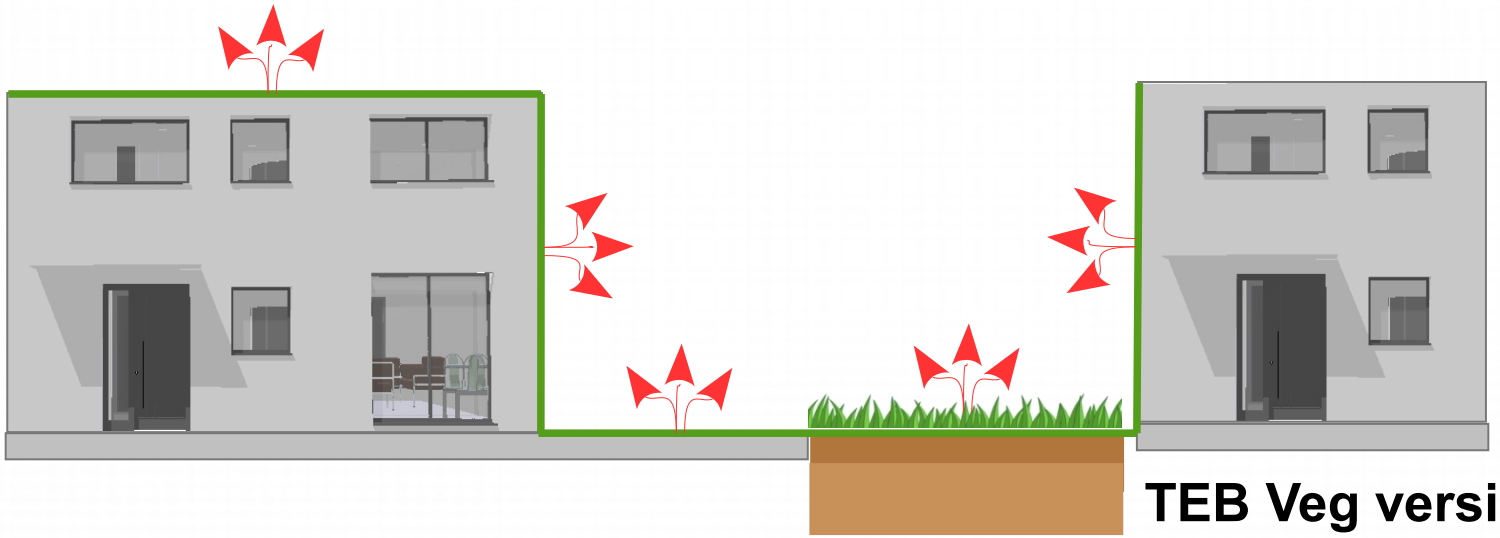
3. **New radiative budget including shadow effects and new reflections, IR emission**

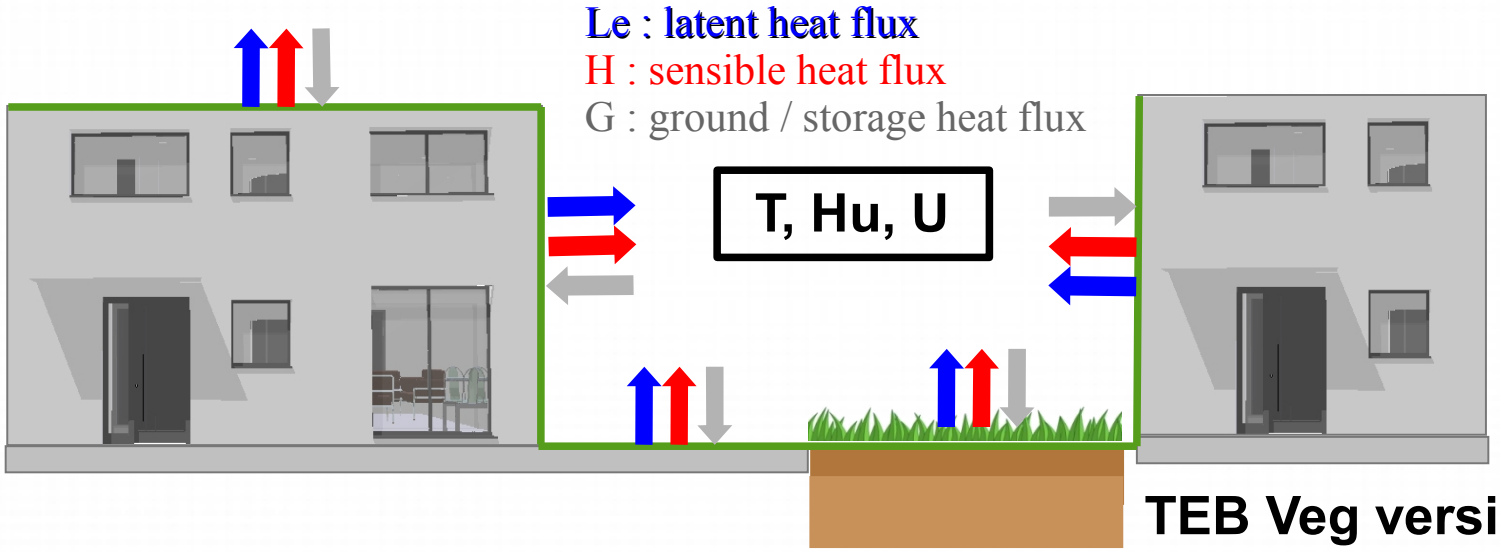
New IR radiations source



TEB Veg version
Lemonsu *et al.*, 2012

III How urban vegetation is represented in TEB model ?

1. Definition of geometric parameters accounting for gardens
2. Integration of gardens inside the urban canyon (as a cover fraction)
3. New radiative budget including shadow effects and new reflections, IR emission
4. **Calculation of turbulent fluxes for vegetation based on the meteorological conditions inside the canyon**
5. **Calculation of urban microclimate (T, Hu, U) including contributions from vegetation**



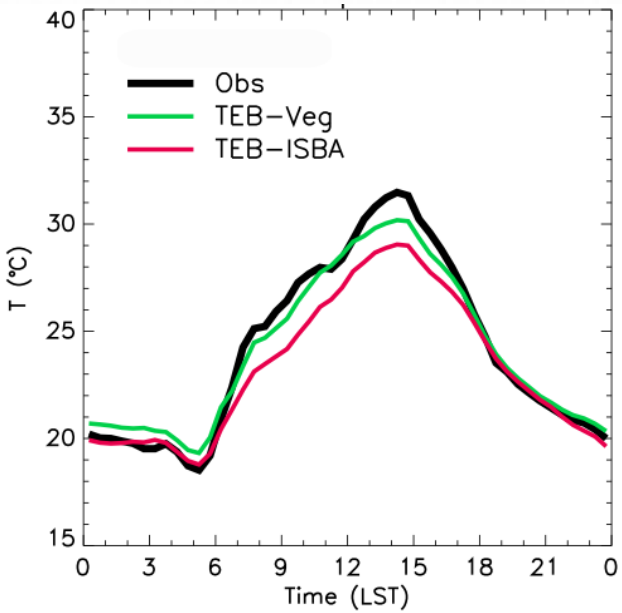
TEB Veg version
Lemonsu *et al.*, 2012

III How urban vegetation is represented in TEB model ?

TEB Veg evaluation by microclimate analysis of landscaping strategies for outdoor comfort in semi-arid region (Sde-Boqer, Israël, Univ. de Negev)

Improvement of air temperature modeling during daytime by TEB Veg

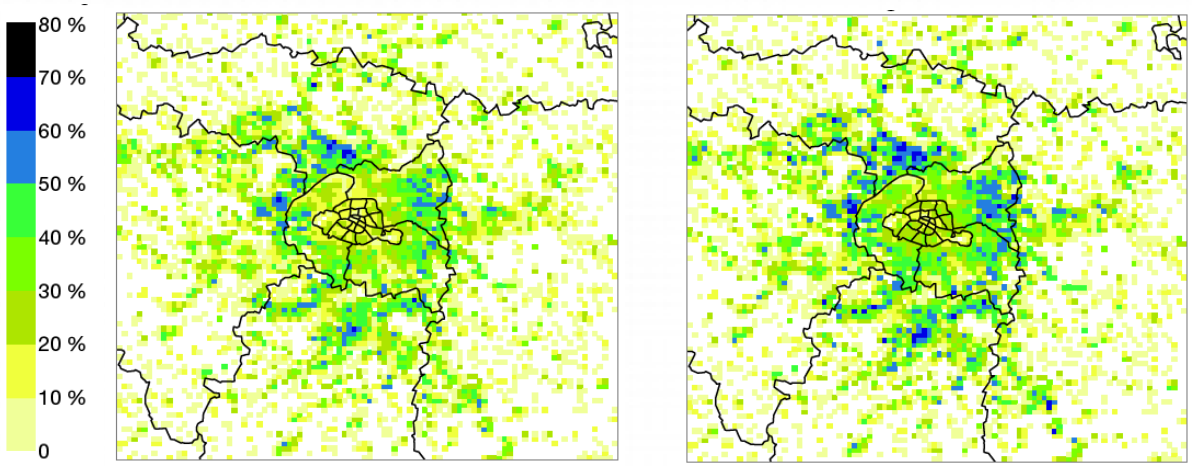
Lemonsu et al., *Geosci. Model Dev,* 2012



TEB-ISBA = simulation using TEB and ISBA without interactions
TEB-Veg = simulation with the new version of TEB including gardens

IV Testing several adaptative strategies, example of Paris city

De Munck, 2013



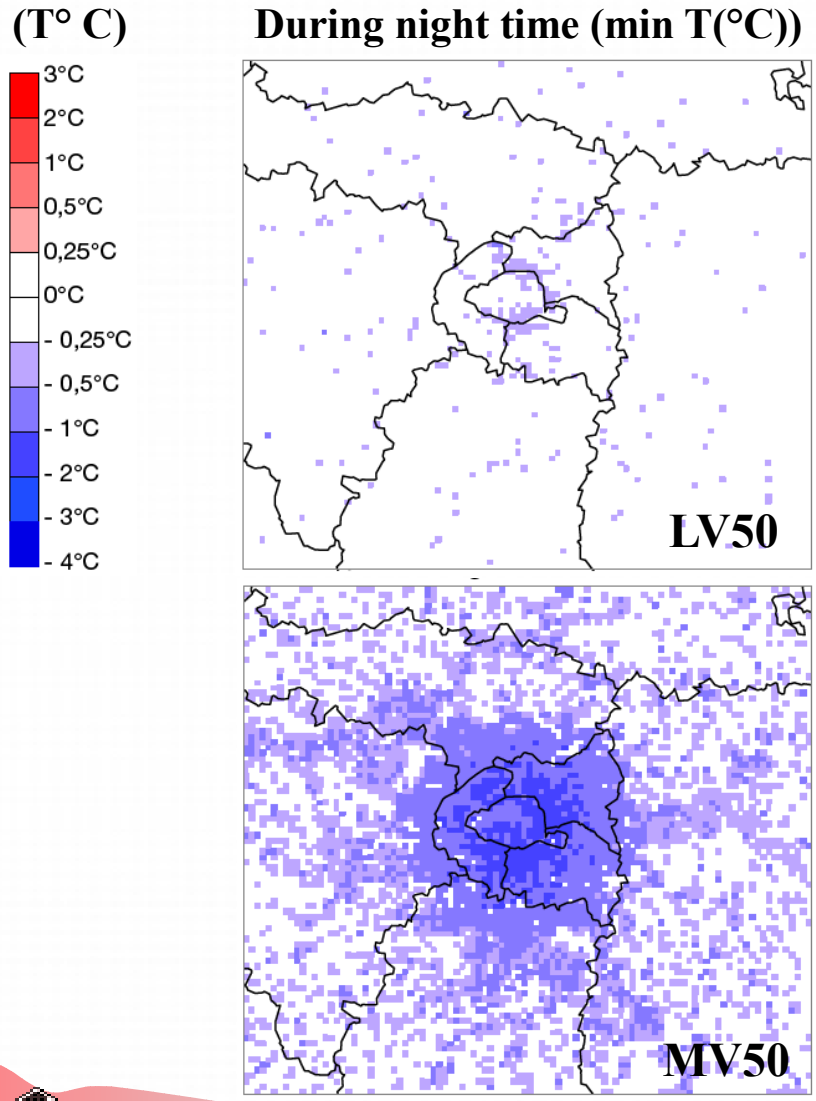
REF **V50**

Available surfaces greening	Area greening
50 %	+ 22 %

REF	Reference status. Current vegetalized cover in Paris
LV50 : 50 % low vegetation greening	Greening of 50 % of available urban surfaces with low vegetation (lawn, bushes) watered by sprinklers
MV50 : 50 % mixed vegetation greening	Greening of 50 % of available urban surfaces with mixed wooded vegetation (40 % deciduous) watered by sprinklers

IV Testing several adaptative strategies, example of Paris city

De Munck, 2013



During night time

Cooling effect :

MV50 >> LV50

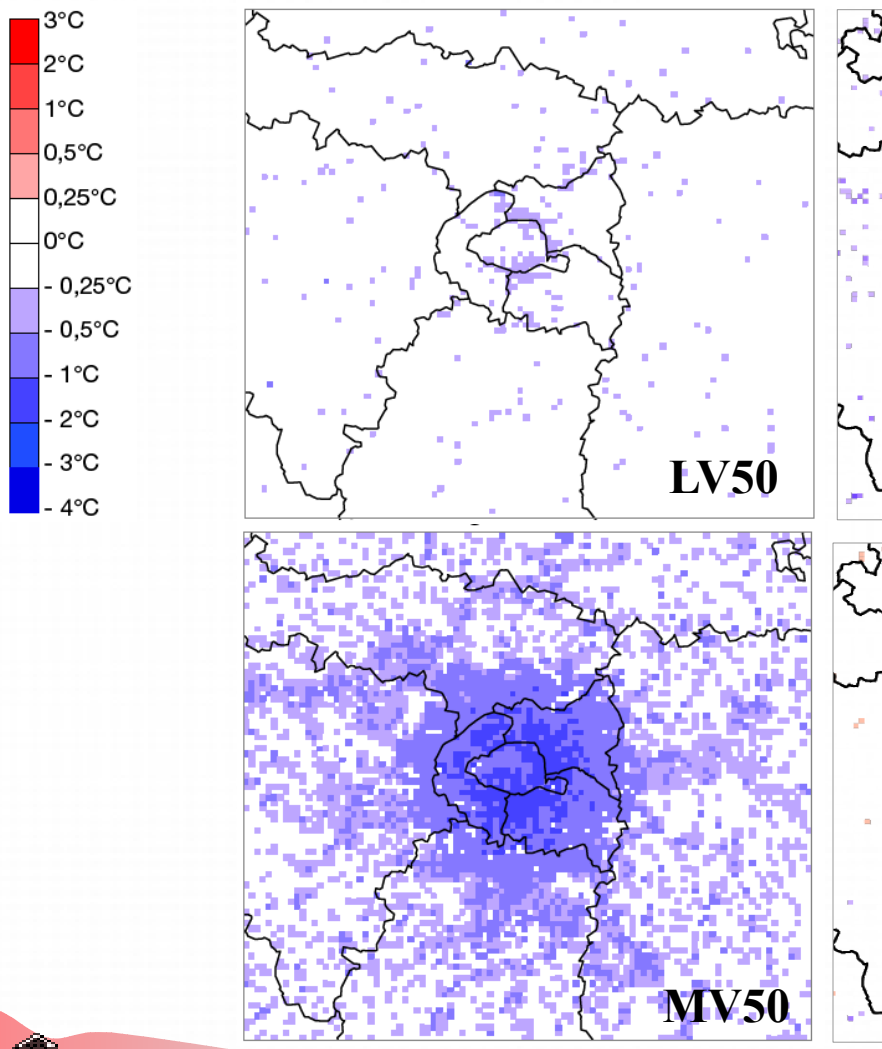
Bias :
Watering = rain forcing

A part intercepted by tree foliage => evaporation

URBTREE

IV Testing several adaptative strategies, example of Paris city

De Munck, 2013



During daytime

Cooling effect :

LV50 > MV50

Bias :

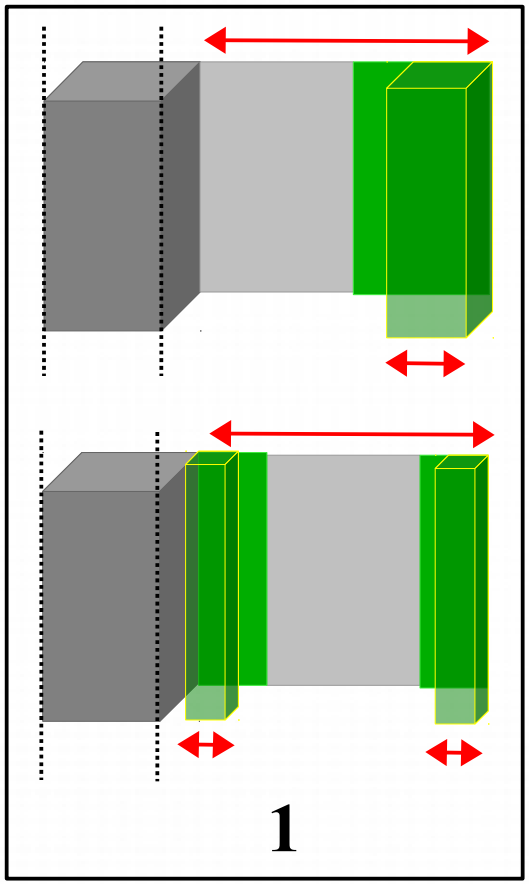
Less available water

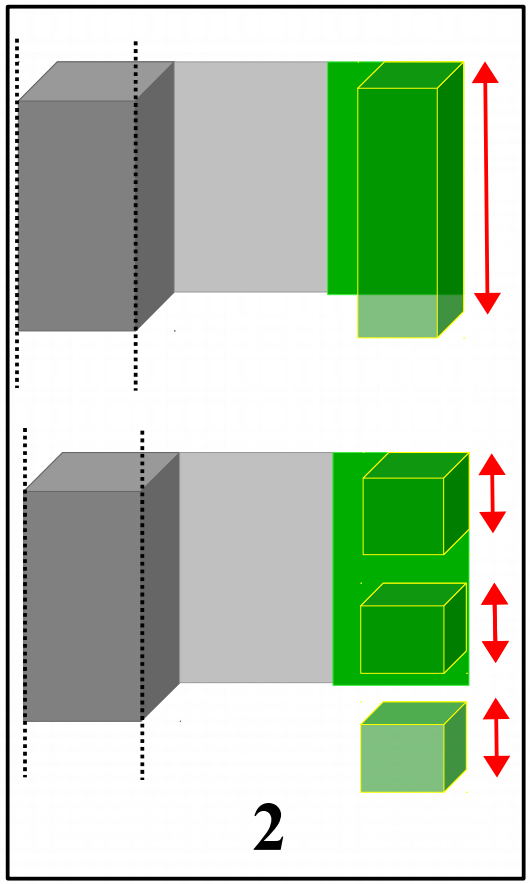
Shadow effect not represented

URBTREE

V Ongoing implementations in TEB Veg

URBTREE module
How high vegetation fraction is defined ?





View from above the street

1

HV fraction in the canyon is computed as the sum of all tree crown widths

2

HV fraction in the canyon is computed taking into account the presence of gaps inside tree lines

TEB Veg version
ongoing work

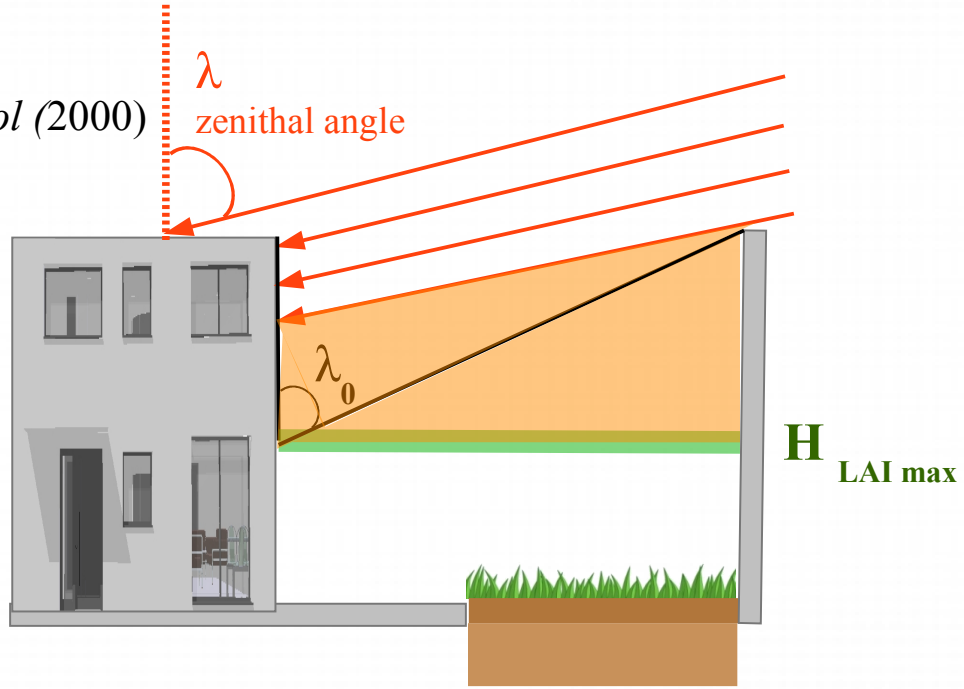
V Ongoing implementations in TEB Veg

URBTREE module

Shading effect

Geometrical solving (λ, $H_{LAI\ max}$)

Adapted from Masson, *Boundary Layer Meteorol (*2000)



TEB Veg version

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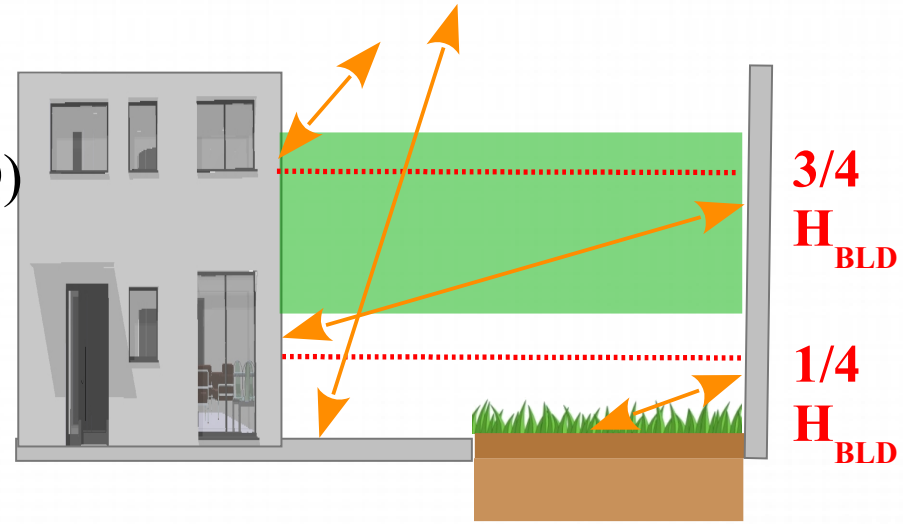
Transmissivity term τ

$\tau_{surf\ /\ surf}$ = exp (-k x LAI or LAD)

Lee & Park, *Boundary Layer Meteorol* (2008)



TEB Veg version

ongoing work

V Ongoing implementations in TEB Veg

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Shading effect
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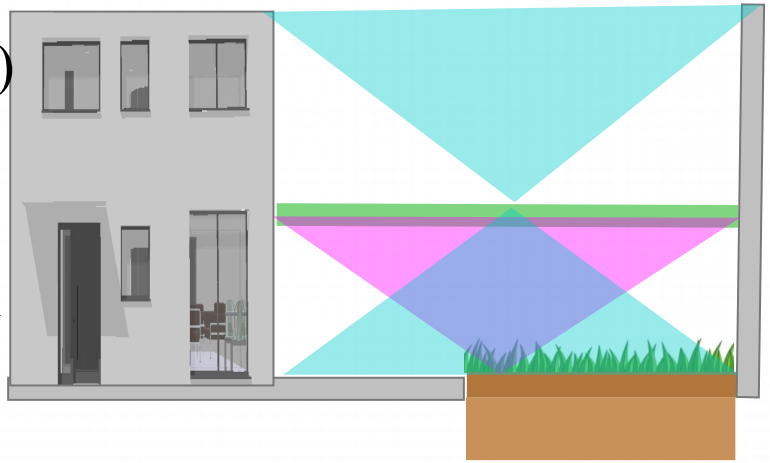
$\tau_{surf\ /\ surf}$ = exp (-k x LAI or LAD)

Lee & Park, *Boundary Layer Meteorol* (2008)

Geometrical factors (Sky View Factor)
share of the visible sky (Φ) above a certain observation point
Φ Ground < HV
Φ HV up + bottom

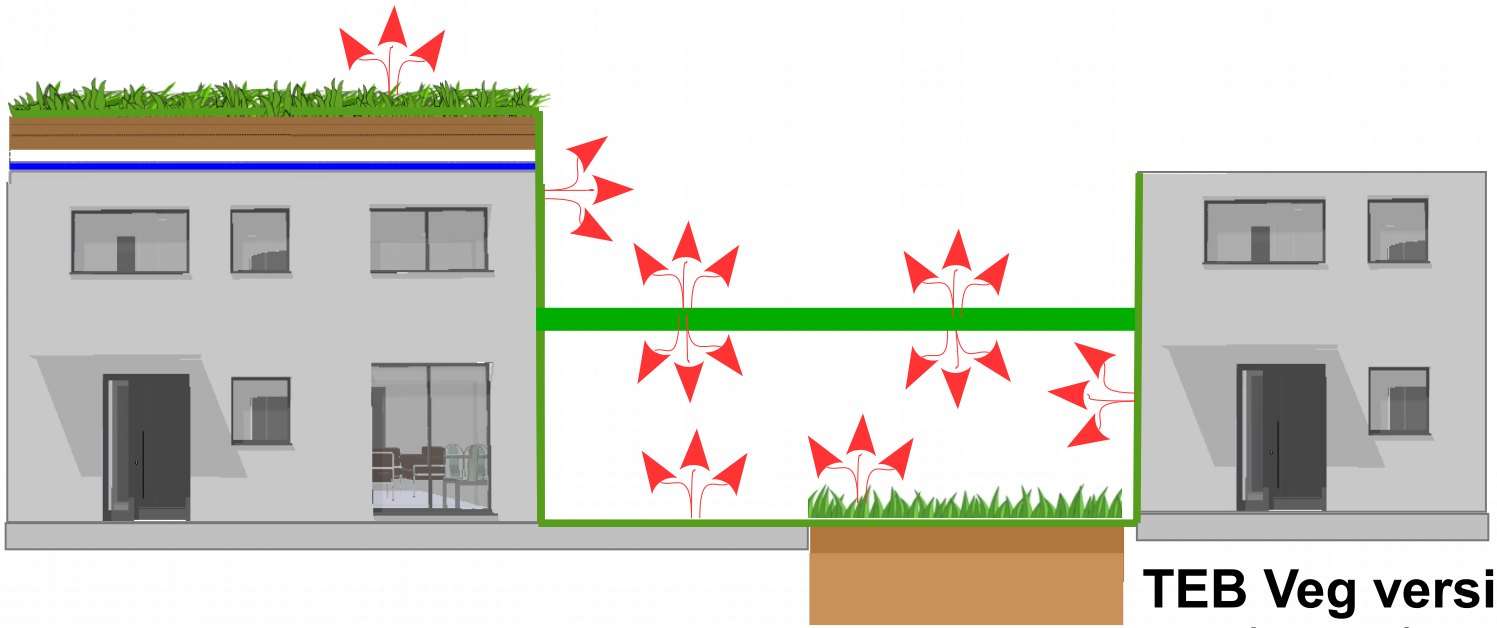


TEB Veg version
ongoing work

V Ongoing implementations in TEB Veg

URBTREE module
How taking into account IR contributions ?

$$LW_{1<2} = 4\ K_B\ \varepsilon_1\ \varepsilon_2\ \text{geom. factors}\ ((T_1 + T_2)/2)\ \text{^3}\ \tau_{1<2}$$

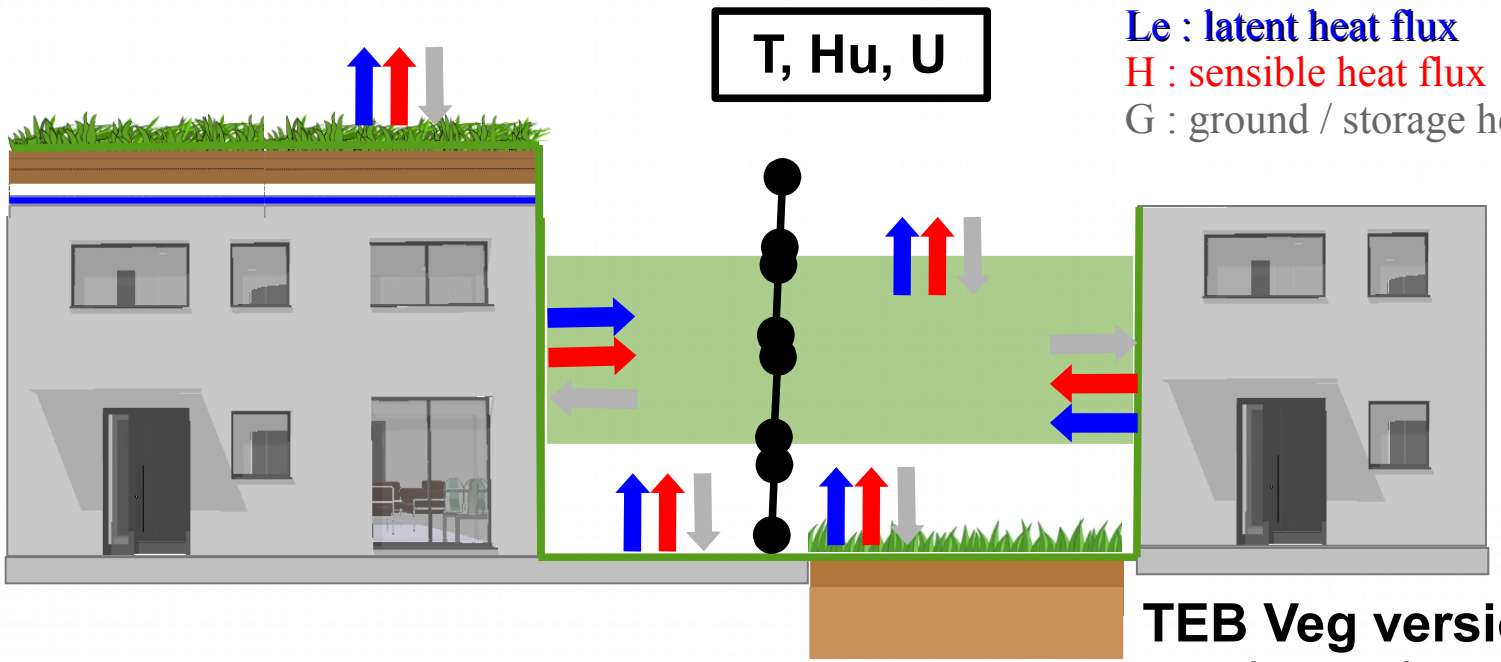


TEB Veg version
ongoing work

V Ongoing implementations in TEB Veg

URBTREE module
+ **TEB BEM** module (**ISBA**) A. Boone
Energy budget

Evapotranspiration => Humidity



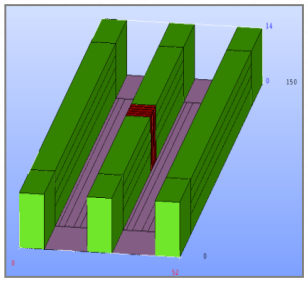
Le : latent heat flux
H : sensible heat flux
G : ground / storage heat flux

TEB Veg version
ongoing work

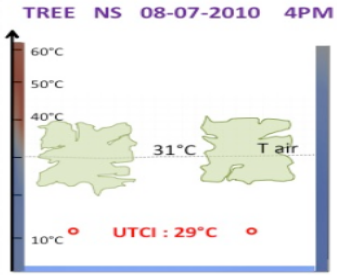
V Ongoing implementations in TEB Veg

URBTREE module :
Evaluation

Ideal cases : Simulations of urban canyon with/without trees by SOLENE model (*CERMA)*



Row of trees



Canyon microclimate
Universal Thermal Climate Index

Experimental data : Radiative and energy budget within a private garden in a residential neighbourhood in Nantes, France*(FluxSAP-2012 campaign, VegDUD projet)*

VI Conclusion (To do list)

TEB Veg version (Lemonsu et al., 2012)
- low vegetation

GREENROOF module (De Munck et al., 2013)

URBTREE module
-radiative budget (in progress)
-energy budget (coming weeks)
+ associated evaluation
Air temperature and UTCI within the canyon
SOLENE simulation vs. TEB Veg modeled comparison

TEB HYDRO (coming months)
+ associated evaluation

Future cities will be made of green

...

But it's already a reality in Singapore (PARKROYAL, © Patrick Bingham-Hall)

THANK YOU FOR YOUR ATTENTION