URBAN MODELING CAPABILITIES AT ENVIRONMENT CANADA

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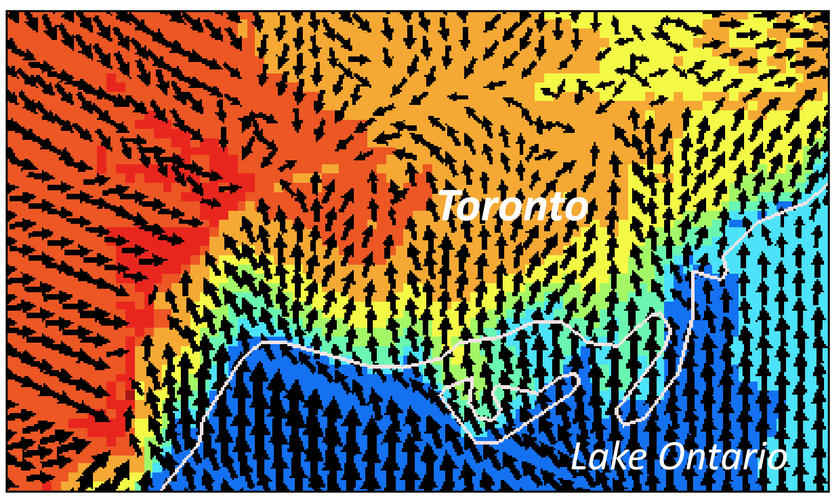


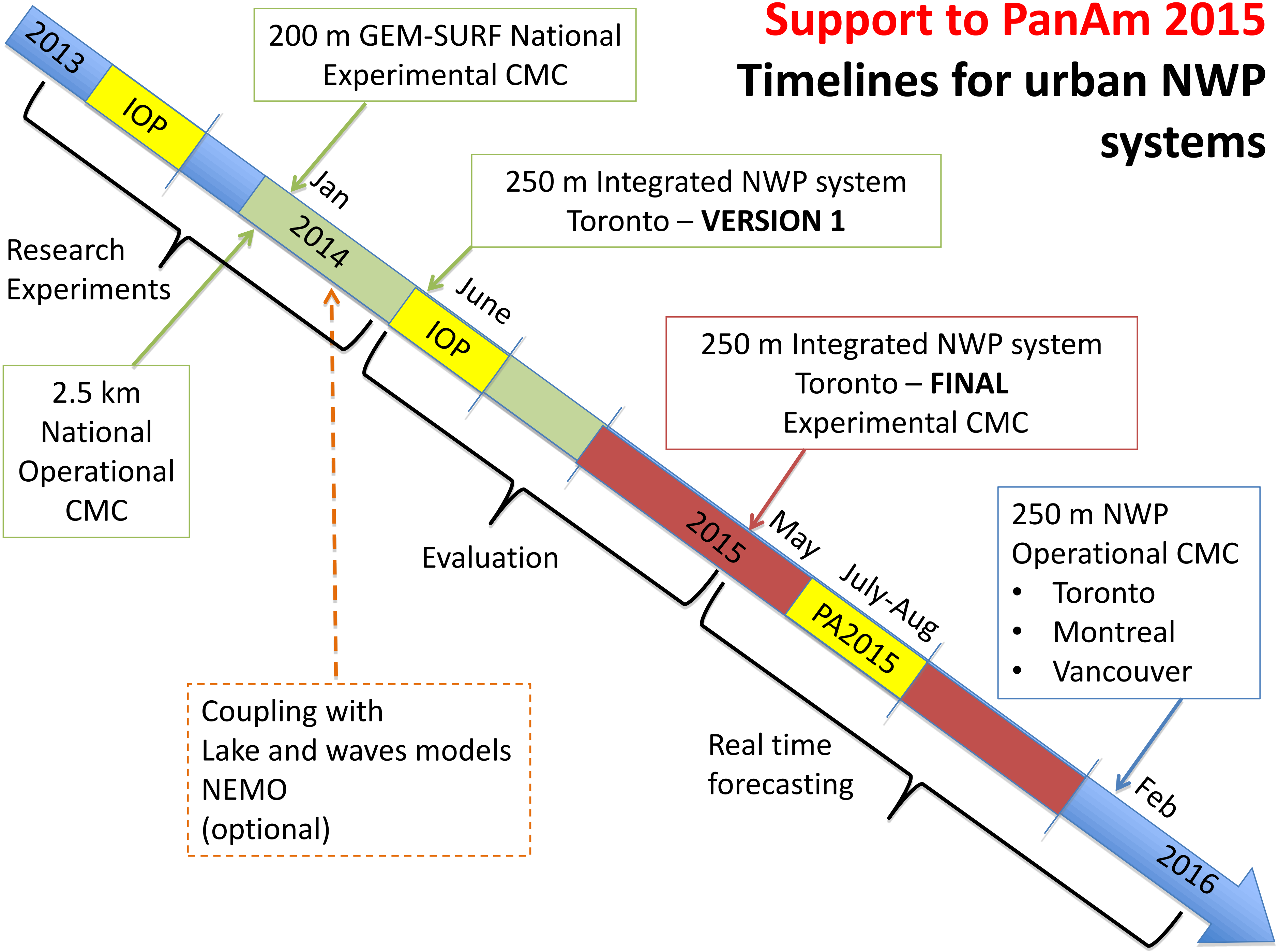
Workshop on the SIMMER project, Toronto, 24 October 2013

Urban Modeling Capabilities at Environment Canada

- Research
  - Projects with Canadian Universities and observational network (EPiCC, MUSE)
  - International project TOMACS (Tokyo, Extreme Weather forecasting)
- Support to special events
  - PanAm / ParaPanAm 2015
  - Olympics Games Tokyo 2020 ?
- Numercial Weather Prediction (NWP)
  - Development of new systems for weather forecasting : Higher resolution + Urban effects
- End-users
  - project studies of mitigation strategies (QC)

Support to PanAm 2015

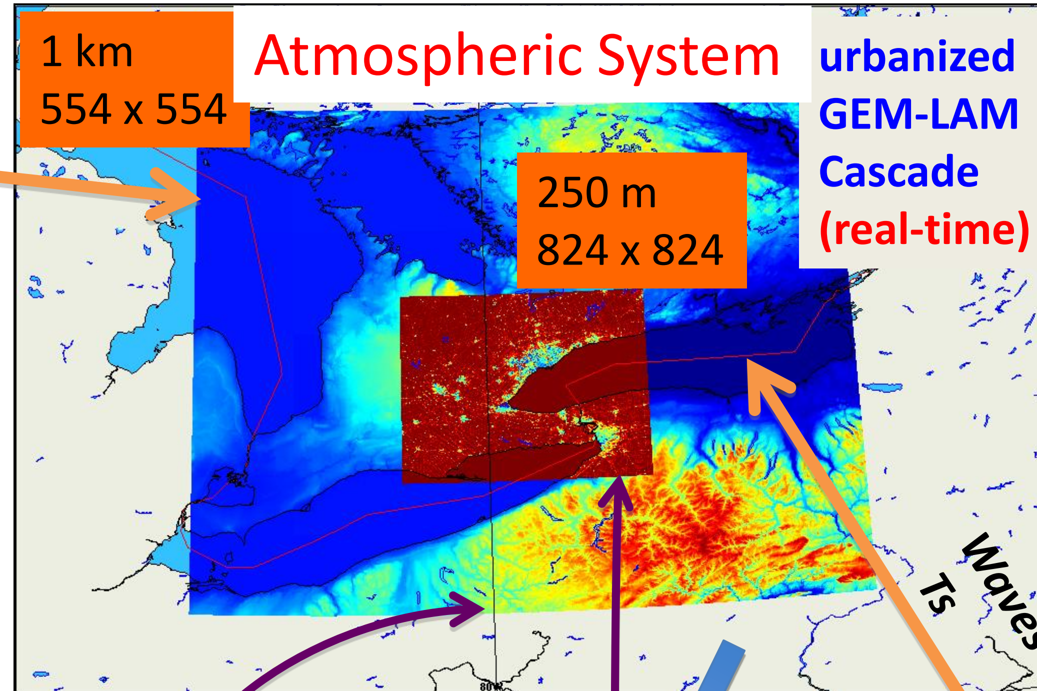
Timelines for urban NWP systems



Support to PanAm 2015 : NWP Integrated System

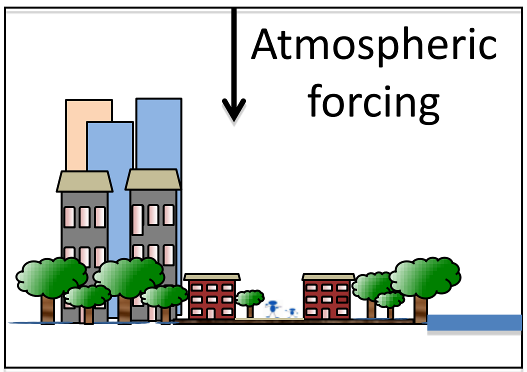
2.5 km National
CMC-Operations
4 runs / day

Upper-air Ics and LBCs



External Surface Modeling

GEM-SURF (200 m)



Canopy/soil physical processes

- TEB (urban)
- ISBA (vegetation), or SVS

Continuous cycle → daily surface forcing

Wall, Road, Roof : Ts
Soil : T, w, snow

Surface Initial conditions

NEMO (lakes)
optional

Outputs & derived products :

- **Outdoor thermal comfort indices** :
  UTCI, WBGT, PHS (heat stress)
- **High impact weather** : heavy rain, strong wind
- Fog / visibility

Support to PanAm 2015 : NWP Integrated System

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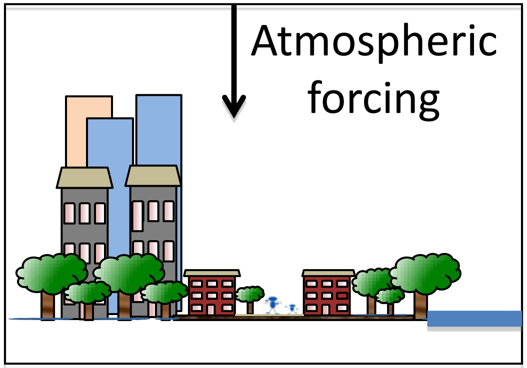


Low cost

Canopy/soil physical processes

- TEB (urban)
- ISBA (vegetation), or SVS

Continuous cycle → daily surface forcing

The core of the Canadian Urban modeling system

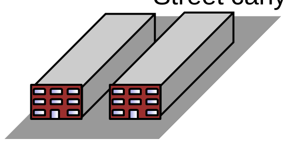
Core:

TEB, Town. Energy Balance

Refs:

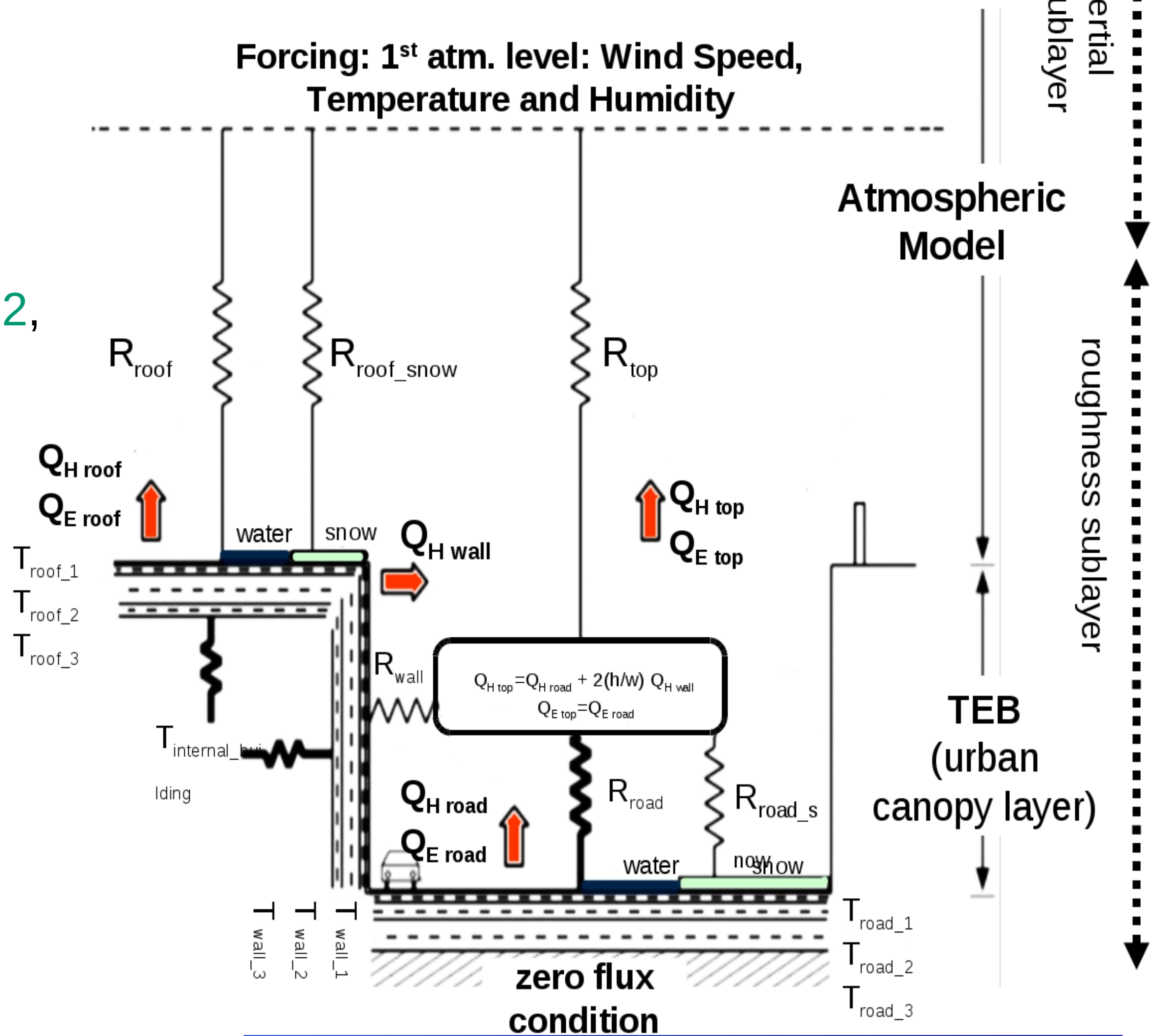
- Masson 2000, Masson et al. 2002,
- Lemonsu et al. 2004
- Leroyer et al. 2010

“Street canyon”



Shadowing effects and multiple radiation reflexions in the canyon

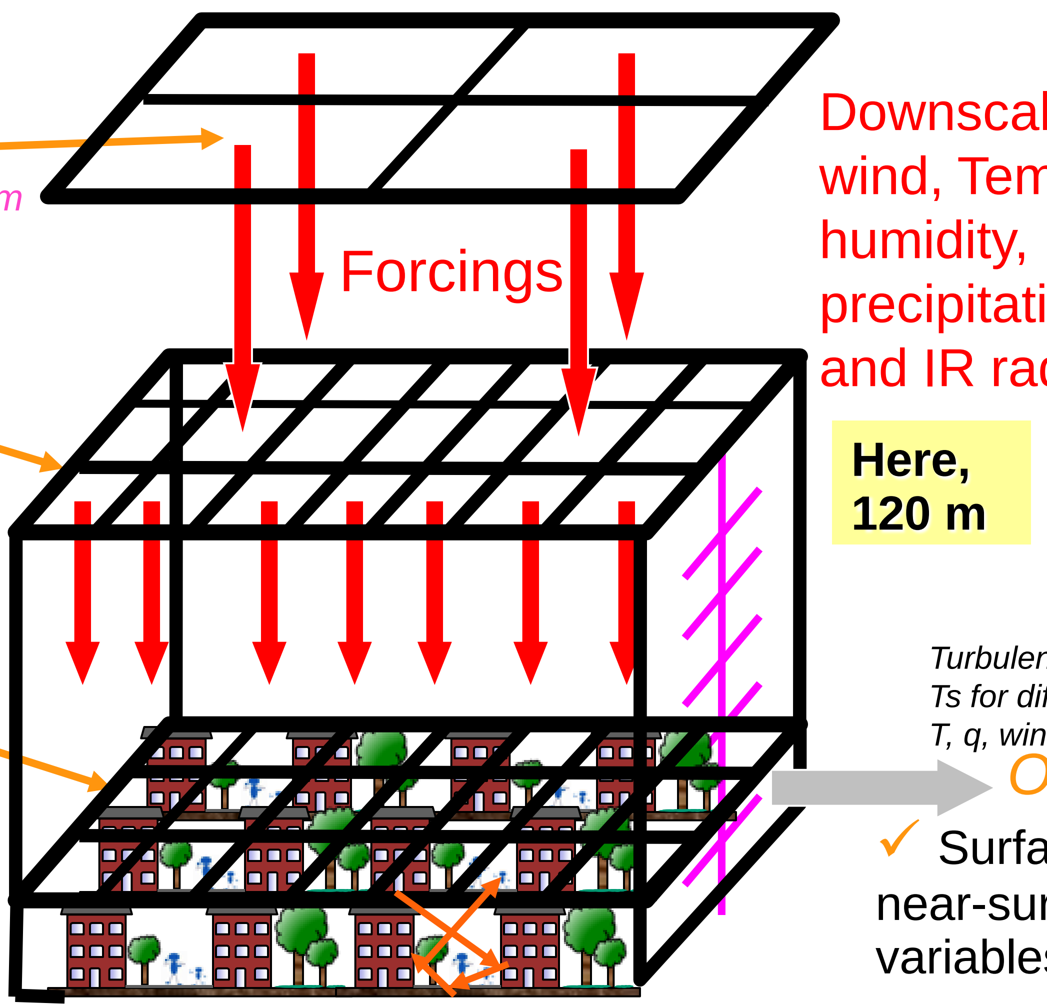
Image adapted from Masson (2000)

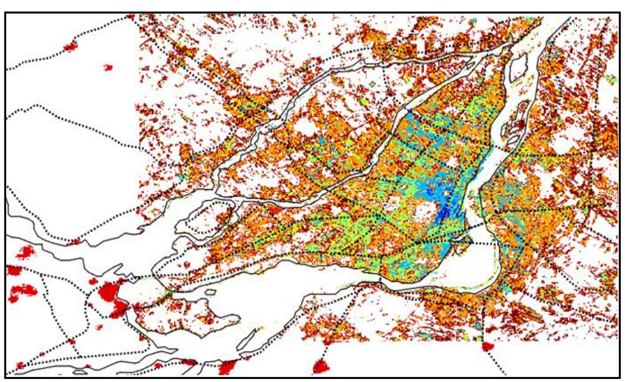


Inputs
- LULC
- Building and road materials (properties)
- Morphology (street aspect ratio, roughness)

Research : urban GEM-Surf over Montreal

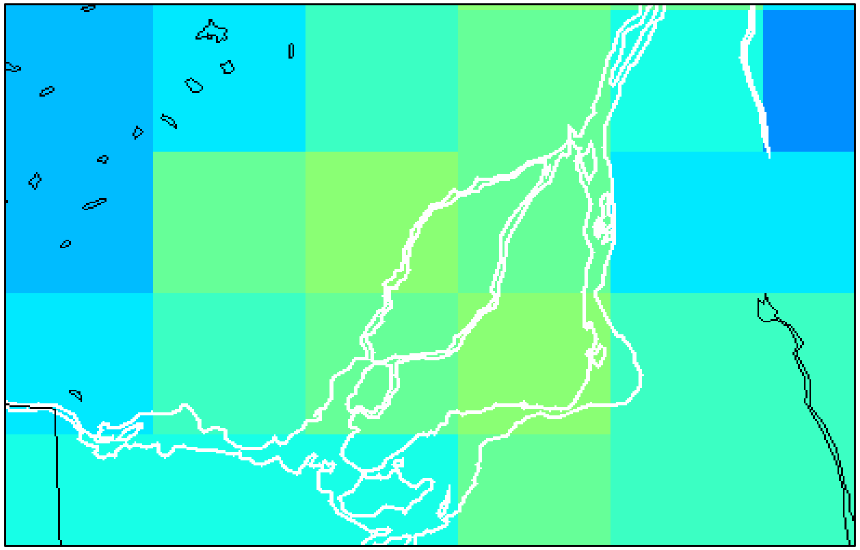
Leroyer et al. (2011)





→ Urban classes (from semi-automatic 60-m classification *(Lemonsu et al. 2006)*

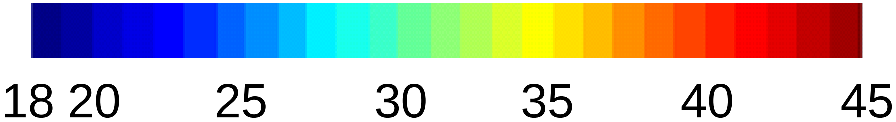
NWP versus this system



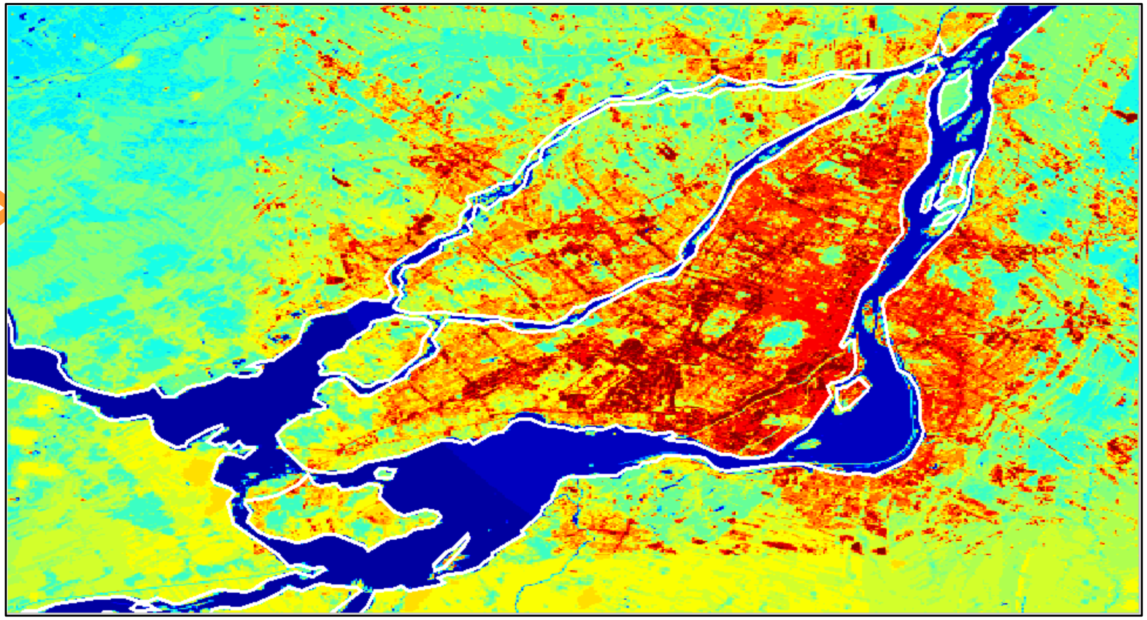
Canadian Operational Model
Product : Regional (North America)
Resolution: 15 km
Data assimilation every day, for :
Soil temperature and water content
(skin and deeper layer)

- **Radiative Surface Temperature (° C)**

July 6th 2008 (11:00 LST)
Warm and Sunny

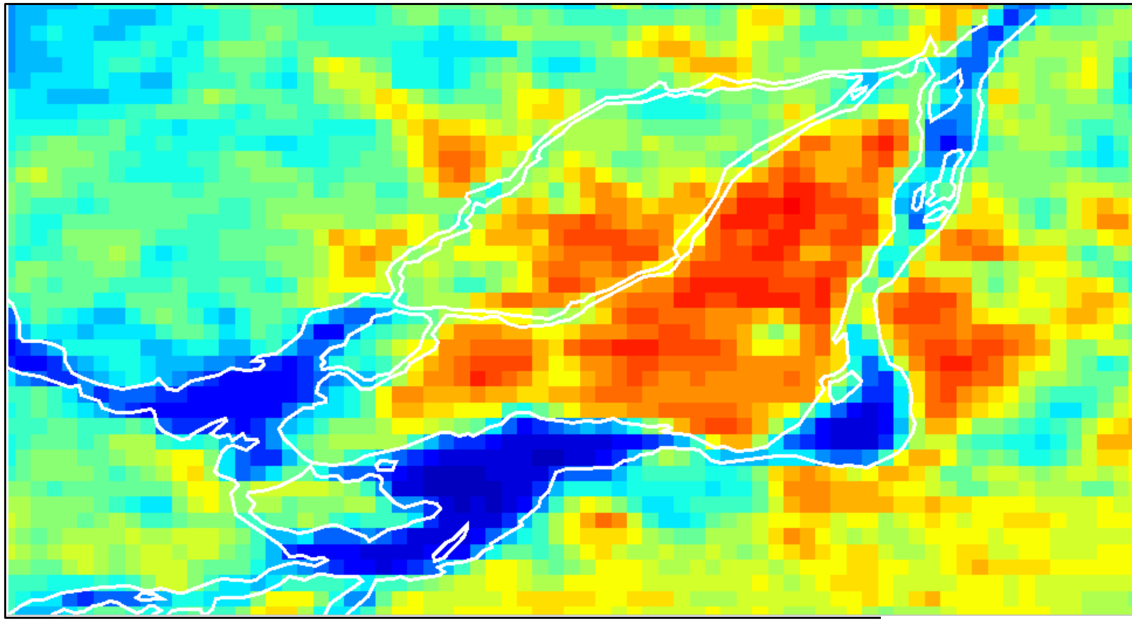


Urban GEM-Surface
Resolution: 120 m



Simulation Period :
May – September 2008
Run Timestep : **30 min**
Forcing Timestep : **1 h**

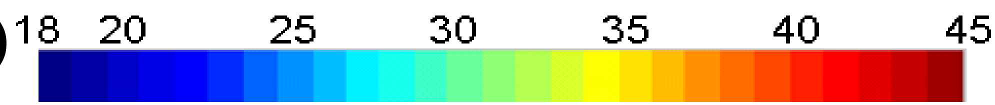
VERIFICATION AGAINST MODIS



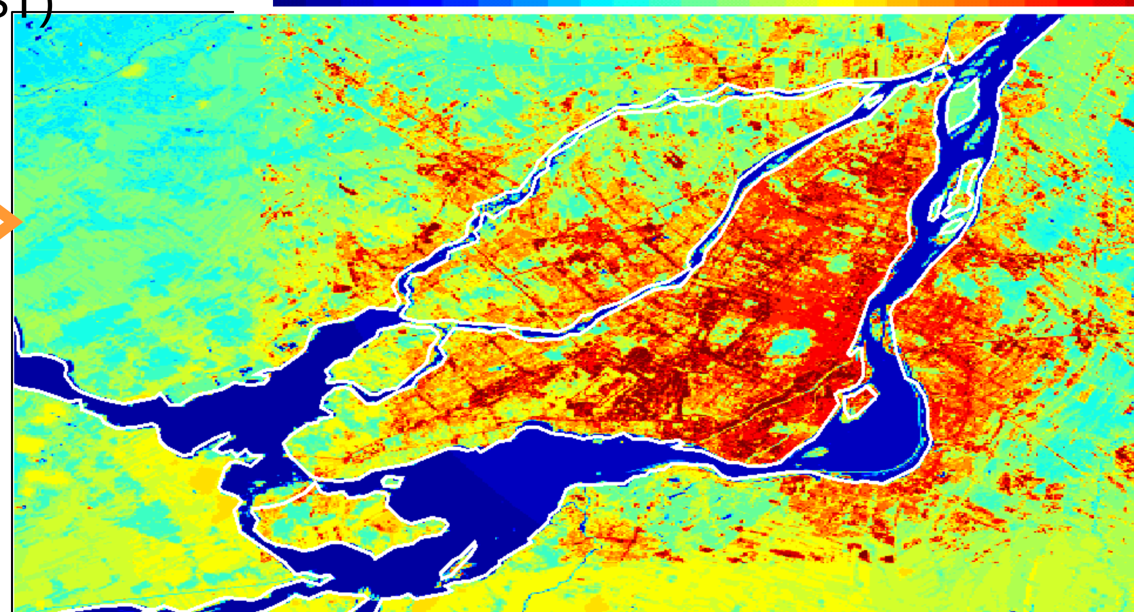
Comparison with MODIS

MOD11A1 product
Resolution: 1km
(exactly 928 m)
■ Atmospheric effects corrected
■ Satellite View Angle : 15°

- **Radiative Surface Temperature (° C)**
  July 6th 2008 (10:54 LST)
  Warm and Sunny



Urban off-line modeling system
Resolution: **120 m**



(Leroyer et al., 2011)

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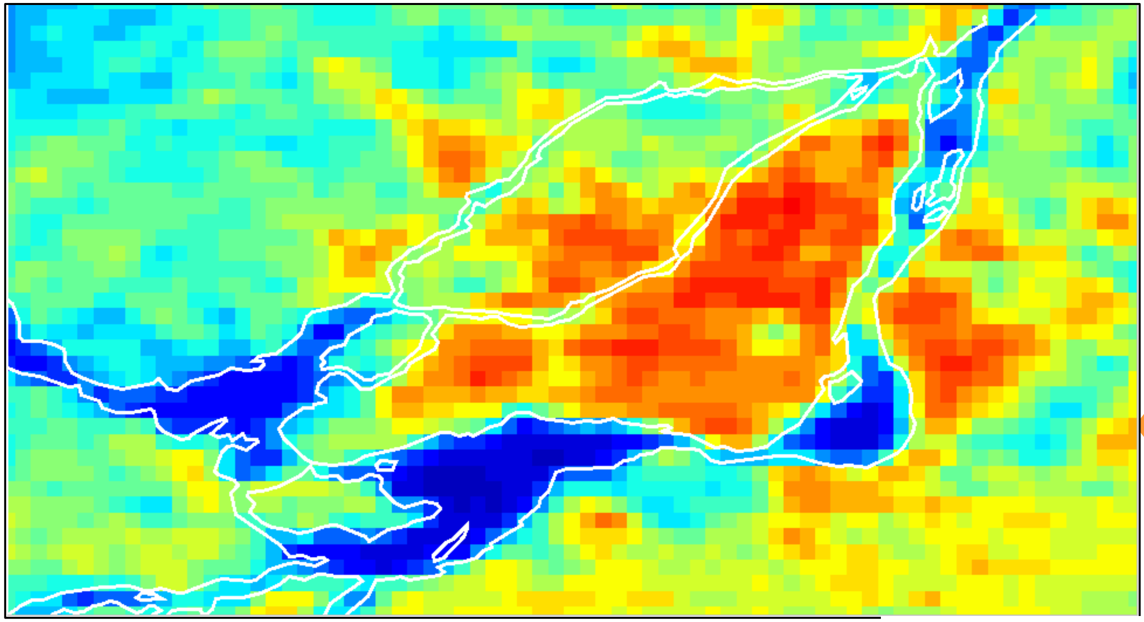

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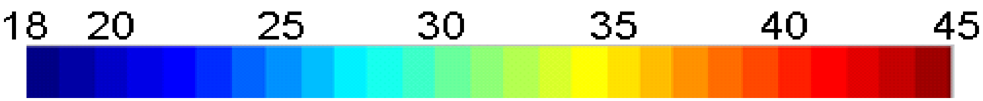
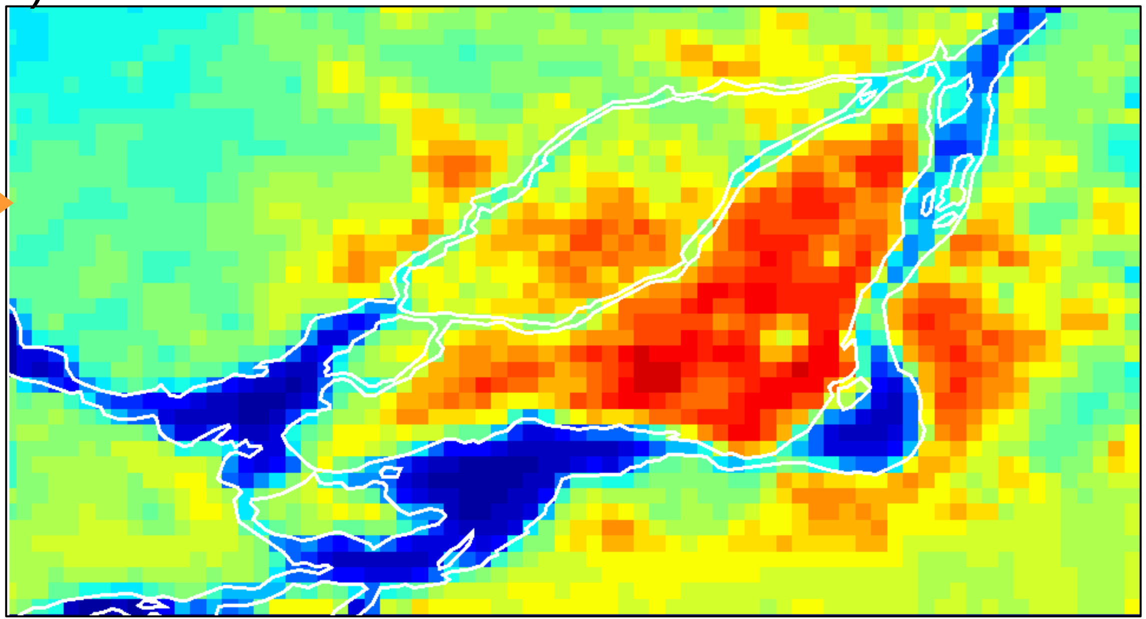


July 6th 2008 (10:54 LST)
Warm and Sunny

Urban off-line modeling system
Resolution: 928 m
→ upscaling

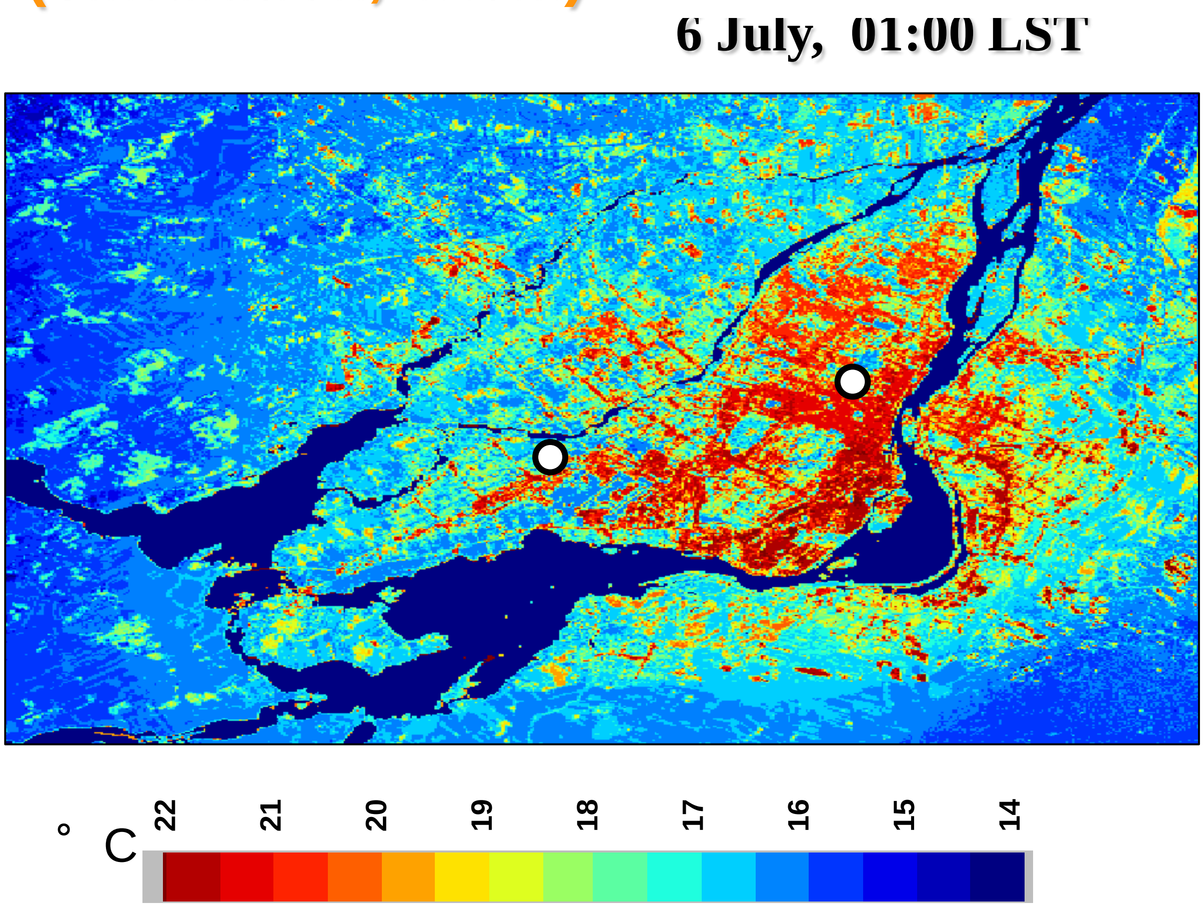


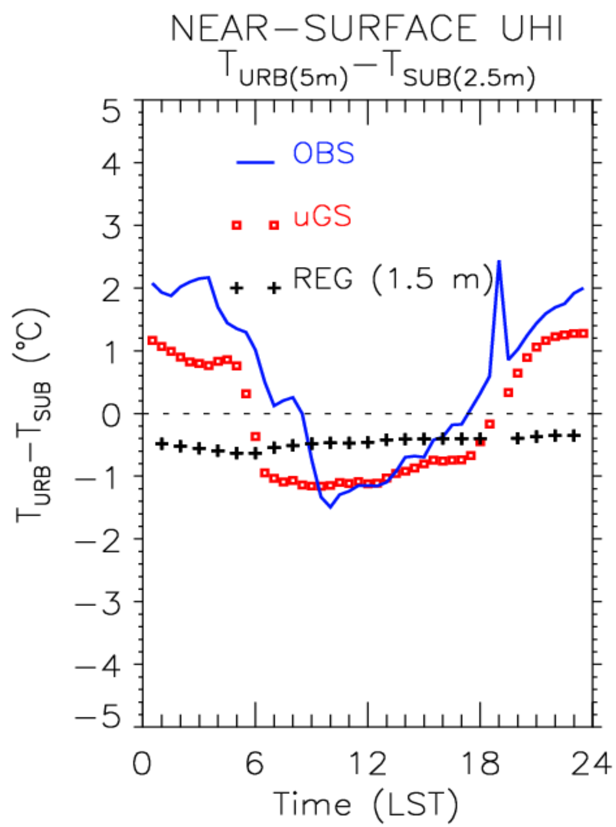
(Leroyer et al., 2011)

Forecast of the Montreal Canopy Urban Heat Island

Nocturnal 2m Air Temperature (simulation, 120m)

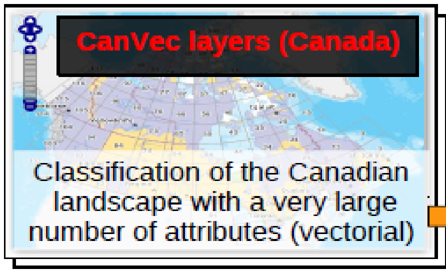
Intra-urban near-surface UHI

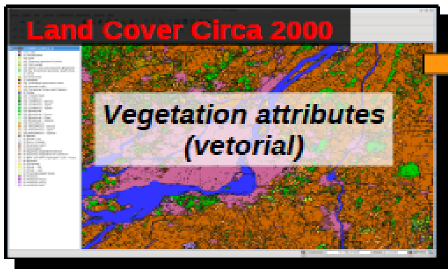


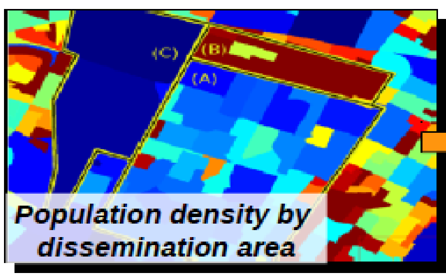


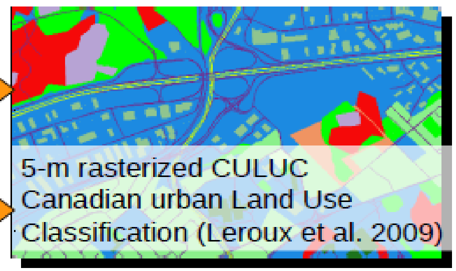
- max UHI : 5-6 ° C

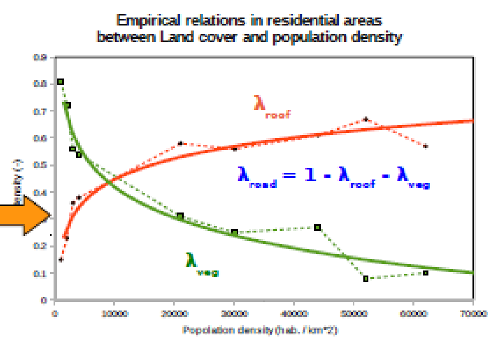
Generation of Country-wide Urban Input Parameters

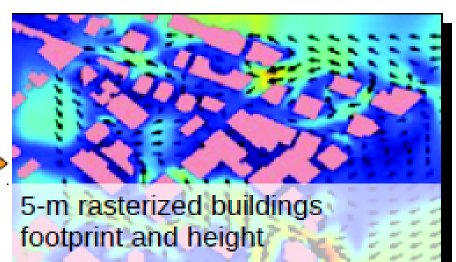












Consistency and priorities, and spatial buffering

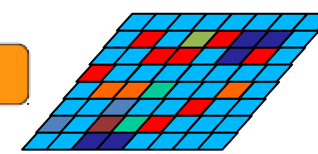
Consistencies

Priorities

Spatial buffering

Look-up Table for each 5-m element (e.g. parking lot element, 100 % road...)	
Land covers	f_{veg}, f_{road}, f_{roof}
Morphological parameters (building height, width, layers thickness)	h_{bld}
	W_{bld}
	d_{roof}^{i}, d_{road}^{i}, d_{wall}^{i} (i=1,2,3)
Radiative parameters (albedo, emissivity)	α_{roof}, α_{road}, α_{wall}
	ε_{roof}, ε_{road}, ε_{wall}
Thermal parameters (capacity, conductivity)	ρc_{roof}^{i}, ρc_{road}^{i}, ρc_{wall}^{i} (i=1,2,3)
	λ_{roof}^{i}, λ_{road}^{i}, λ_{wall}^{i} (i=1,2,3)
Anthropogenic heat fluxes (sensible and latent)	$Q_H^{traffic}$, $Q_E^{traffic}$
	$Q_H^{industry}$, $Q_E^{industry}$
Aerodynamic surface roughness	$z_{0\ roof}$, $z_{0\ road}$

grid-cell aggregation



Grid-scale parameters	
Wall to horizontal surface ratio	$F_{walls} = 2\, h_{bld}\, f_{roof} / W_{bld}$
Frontal aspect ratio	$\lambda_F = F_{walls} / 2$
Canopy aerodynamic roughness	$z_{0\ canopy}$ (Macdonald et al., 1998)

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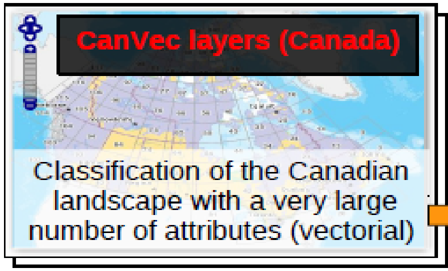

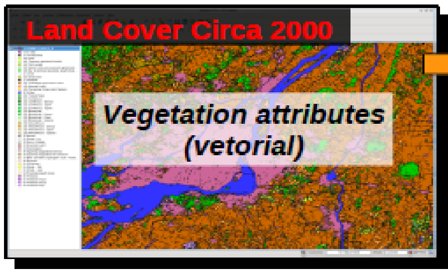

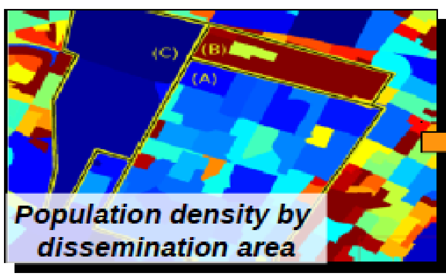

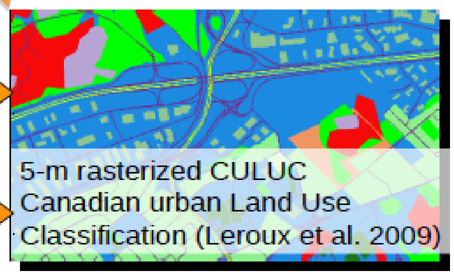

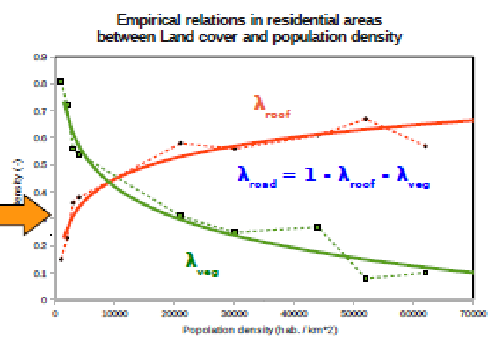

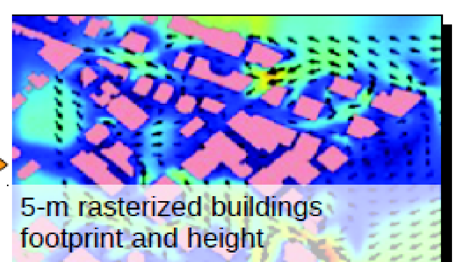

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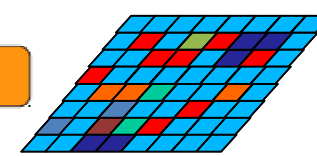

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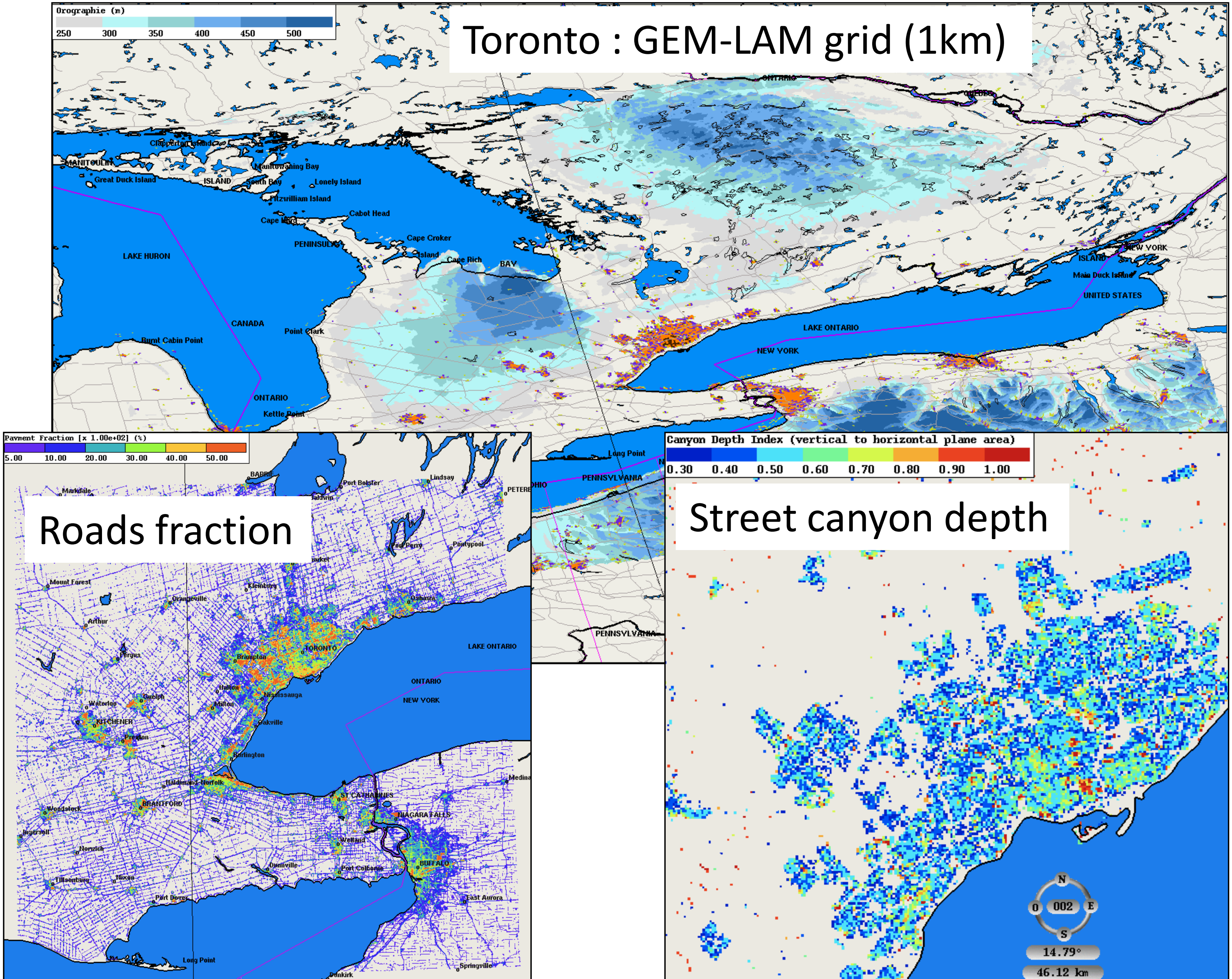

Toronto : GEM-LAM grid (1km)
Orographie (m)
250 300 350 400 450 500
Roads fraction
Pavment Fraction [x 1.00e+02] (%)
5.00 10.00 20.00 30.00 40.00 50.00
Street canyon depth
Canyon Depth Index (vertical to horizontal plane area)
0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
LAKE HURON
LAKE ONTARIO
CANADA
ONTARIO
NEW YORK
UNITED STATES
PENNSYLVANIA
TORONTO
BUFFALO
14.79°
46.12 km

Support to PanAm 2015 : NWP Integrated System

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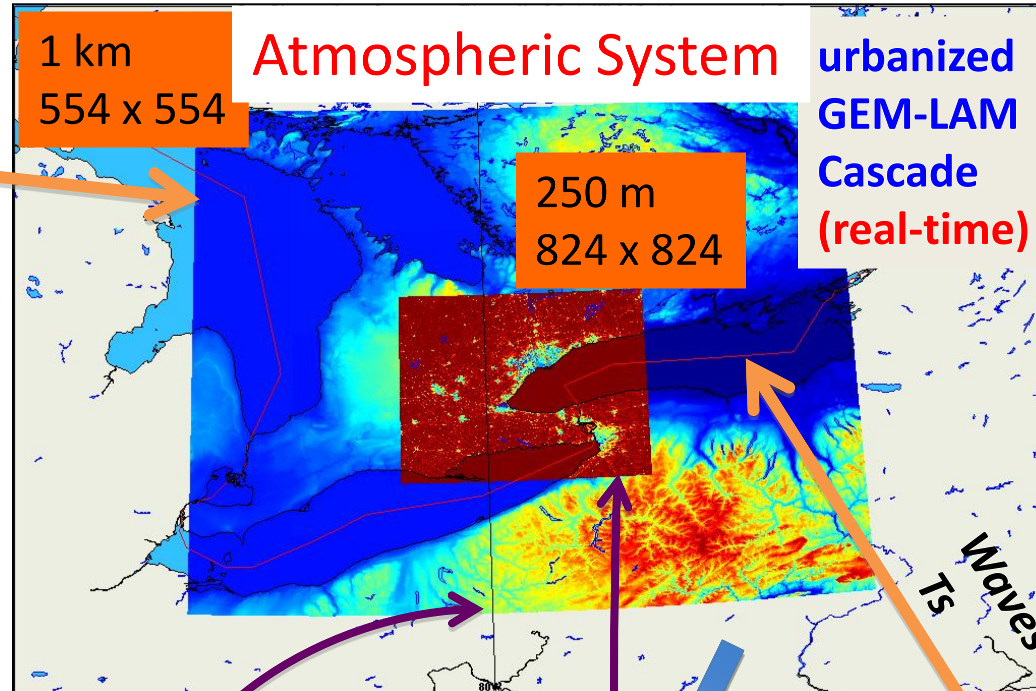
CMC-Operations
4 runs / day

Upper-air Ics and LBCs



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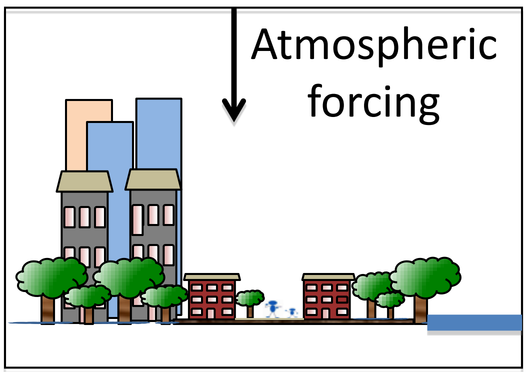

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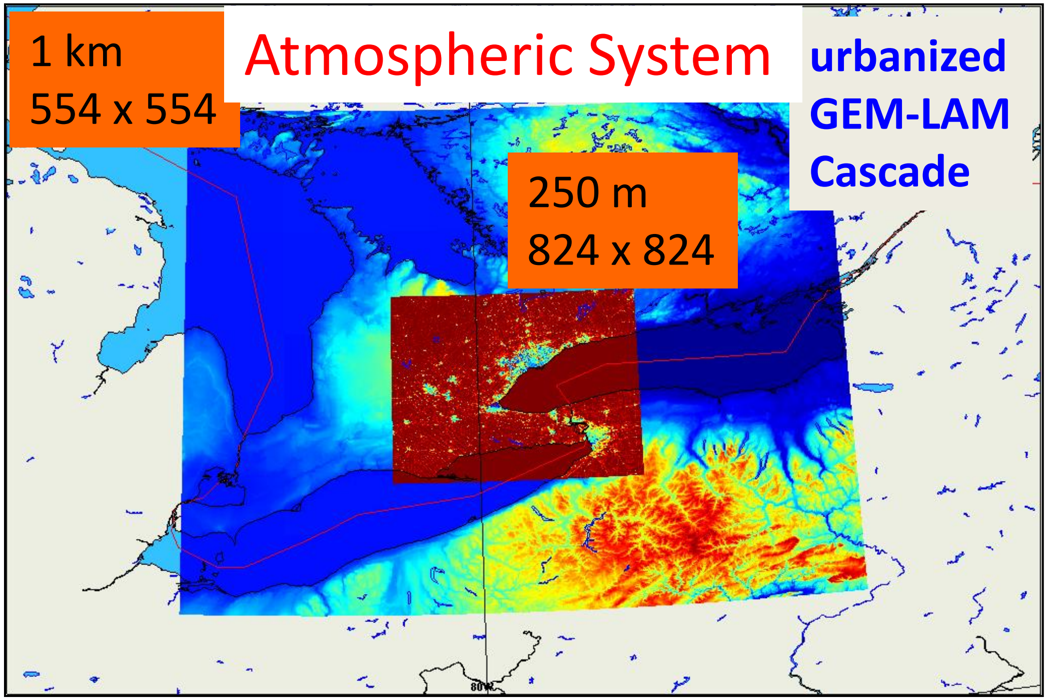
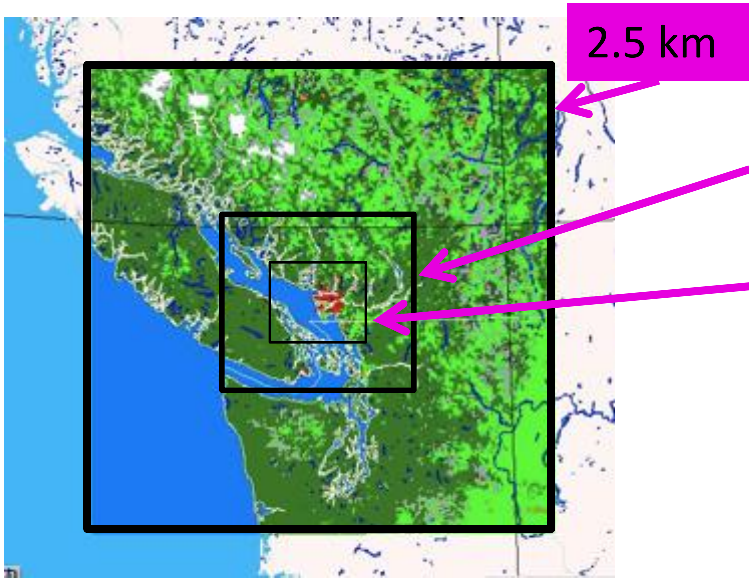
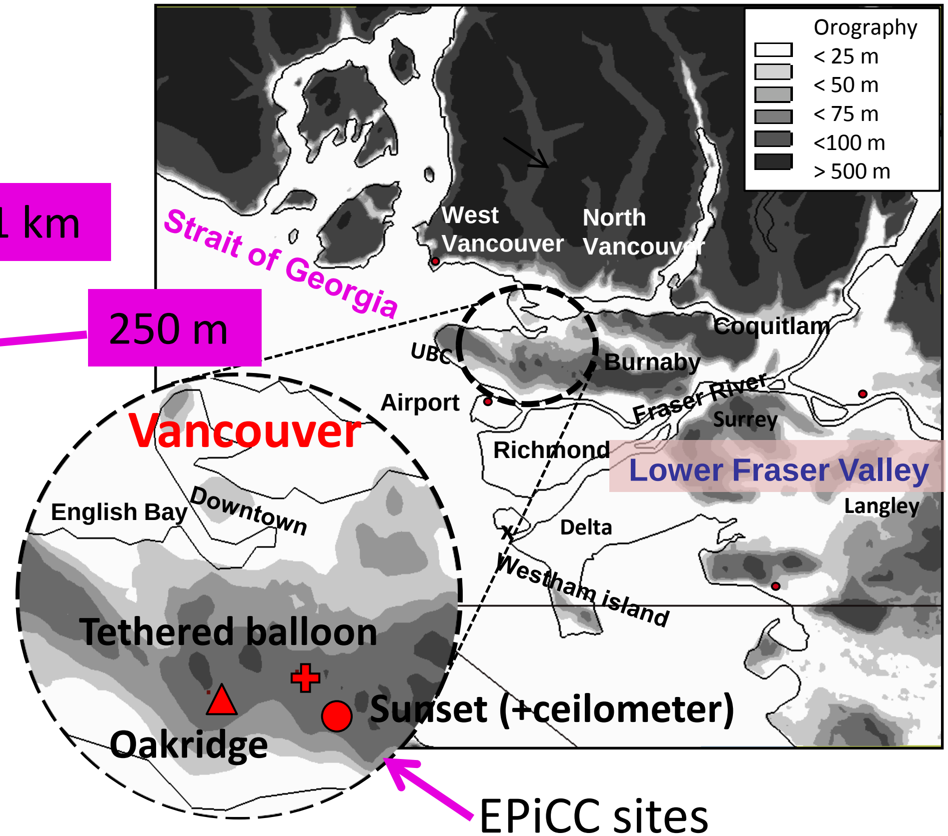


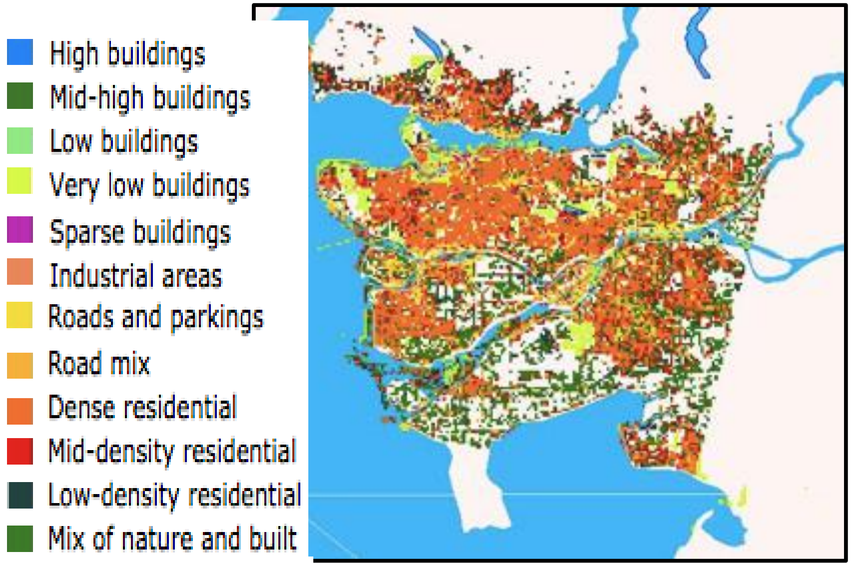
Research : Coastal Urban Modeling with GEM-LAM

Leroyer et al. (2013), *in revision*





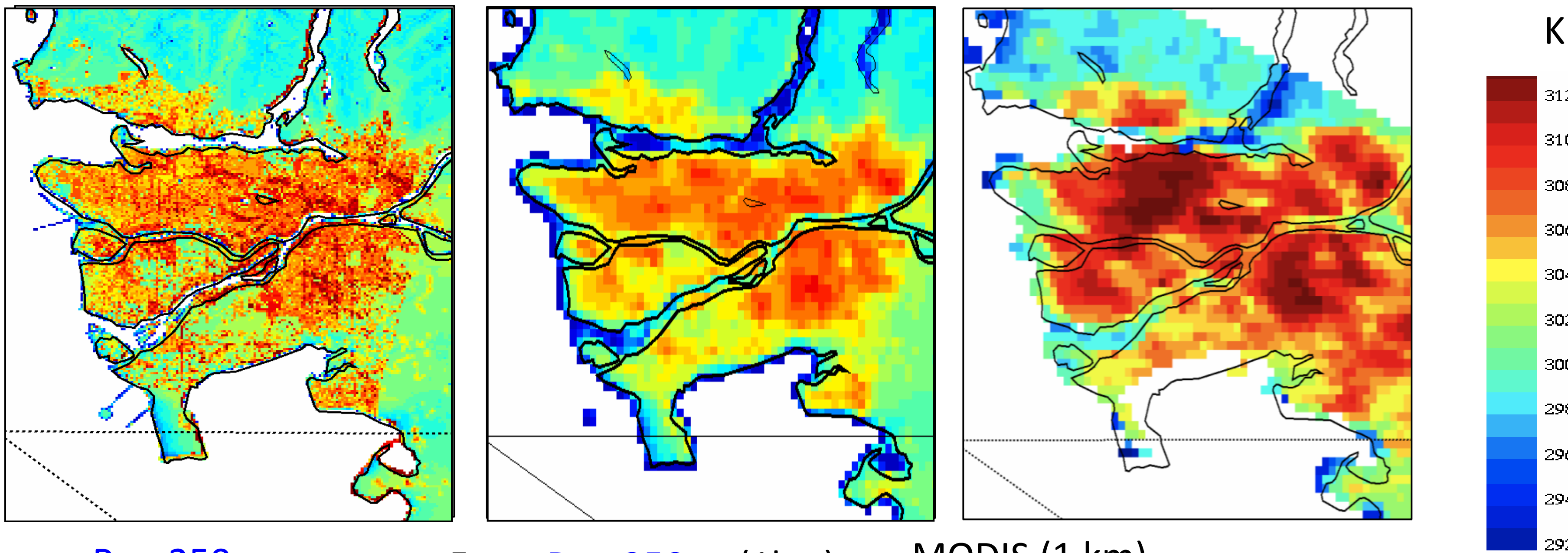
Urban classes (eg : 250 m)



→ Sea-breeze event (14-15 Aug. 2008)
→ EPiCC IOP (Environment Prediction in Canadian Cities network)
→ Nested in RDPS
→ **33 hours studied**

Evaluation of the Urban Thermal Forcing

Radiative Surface Temperature   Satellite view angle : -12 degrees. Time : 1100 LT



Run 250 m

From Run 250 m (1km)
(upscaled, + spatial filter)

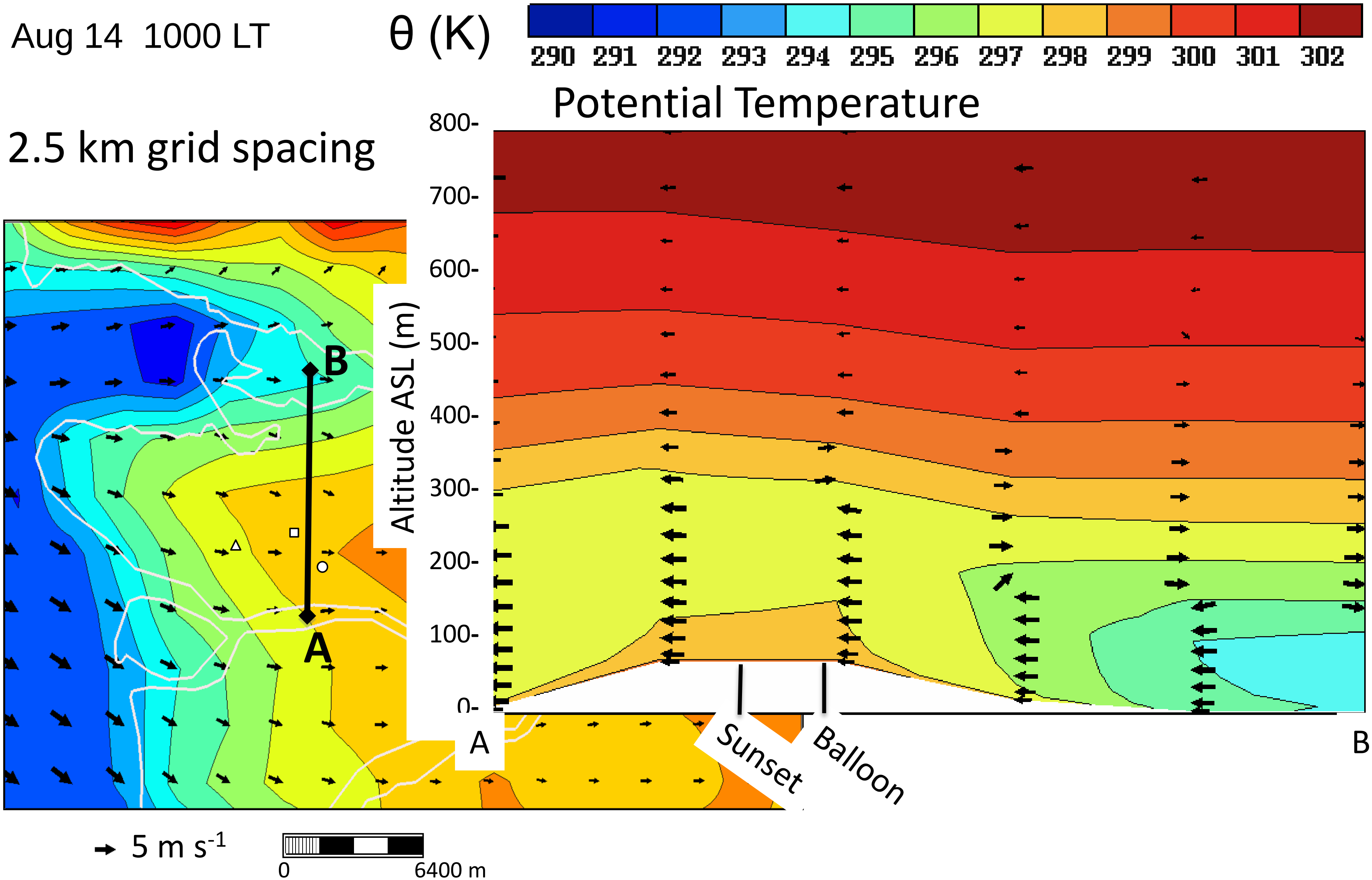
MODIS (1 km)
(MOD11A1, satellite Terra)

Influence of the model grid spacing + urban effects

Statistics over urban pixels	Resolution	250 m	1 km	2.5 km
With Urban effects	STDE	**2.6**	3.0	3.4
No urban effects	STDE	3.6	3.4	**4.3**

Convergence zone over the suburban areas

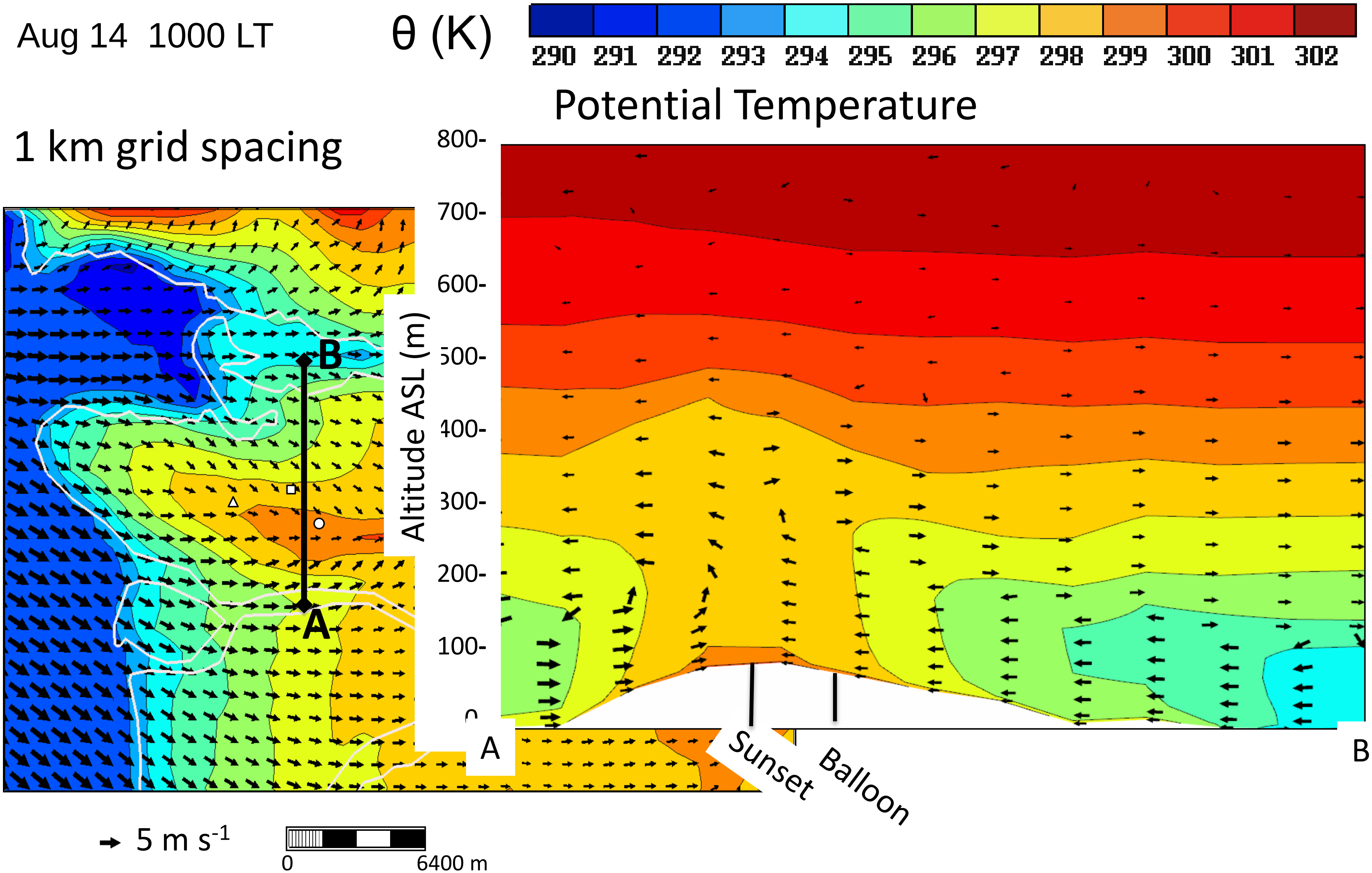
Influence of the grid spacing in the model



Convergence zone over the suburban areas

Influence of the grid spacing in the model

Aug 14 1000 LT

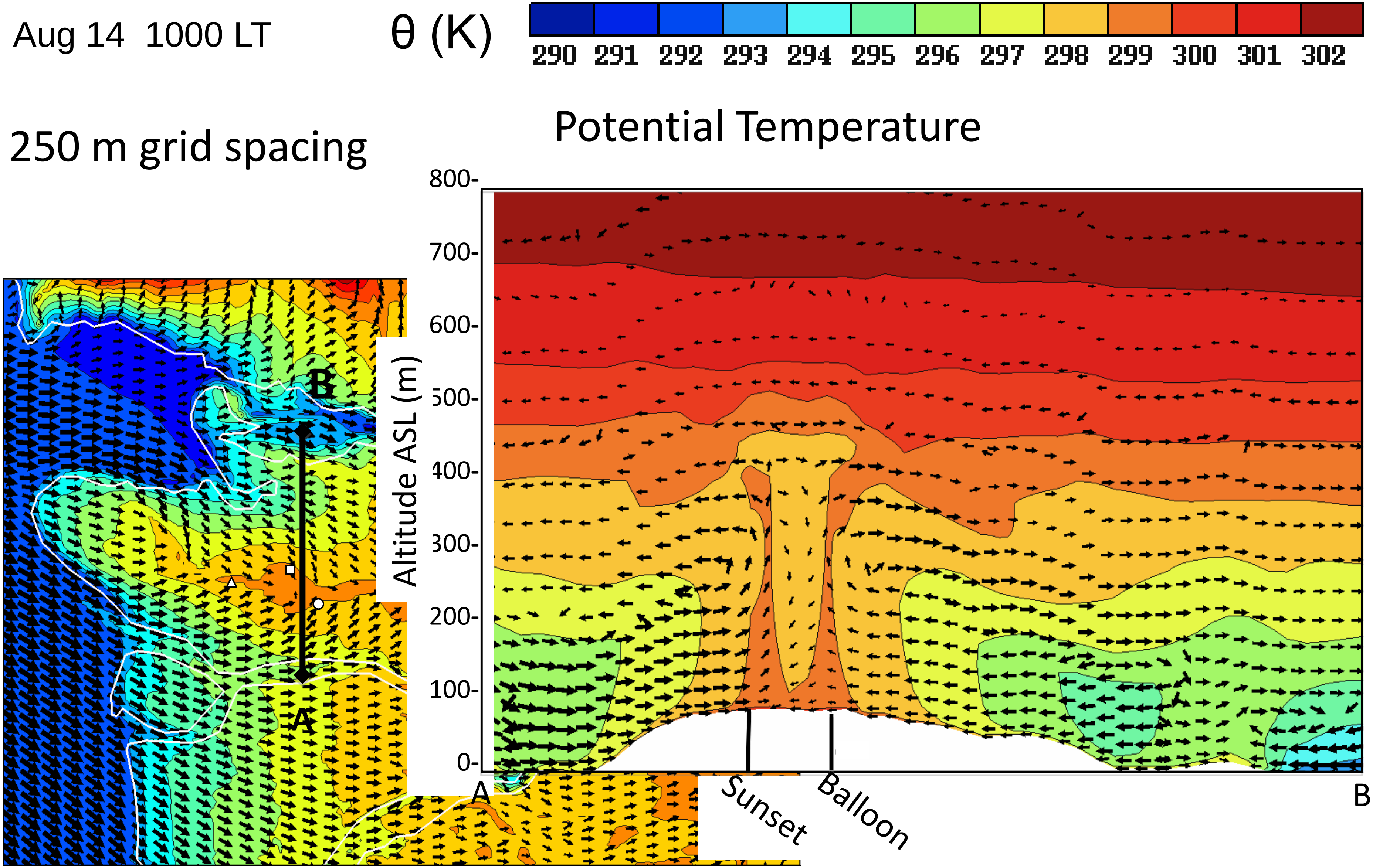


Convergence zone over the suburban areas

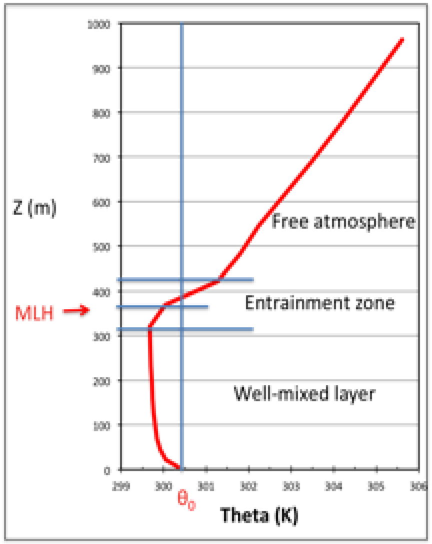
Influence of the grid spacing in the model

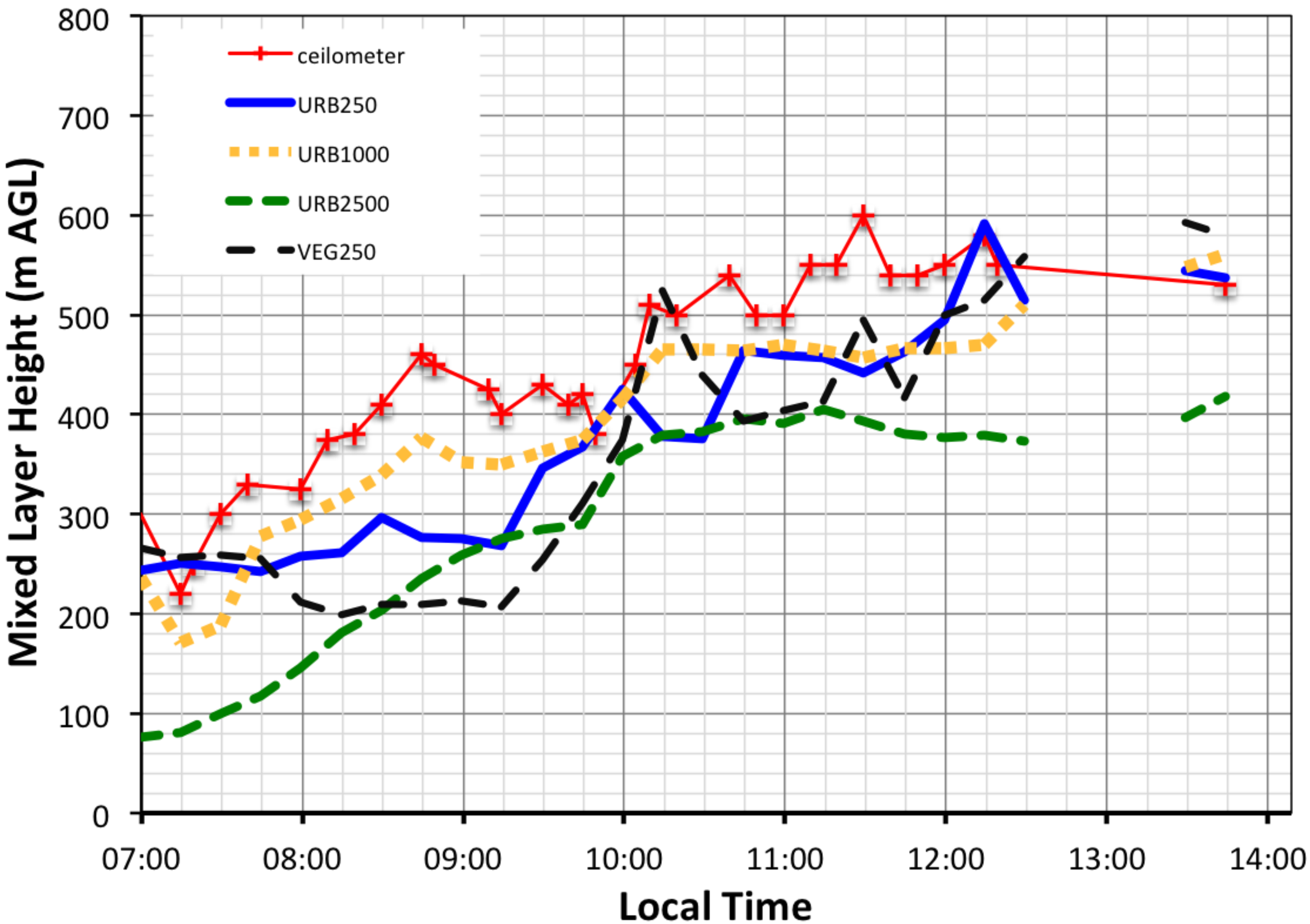
Aug 14 1000 LT

250 m grid spacing



Evaluation of the Mixed Layer Height (Ceilometer)

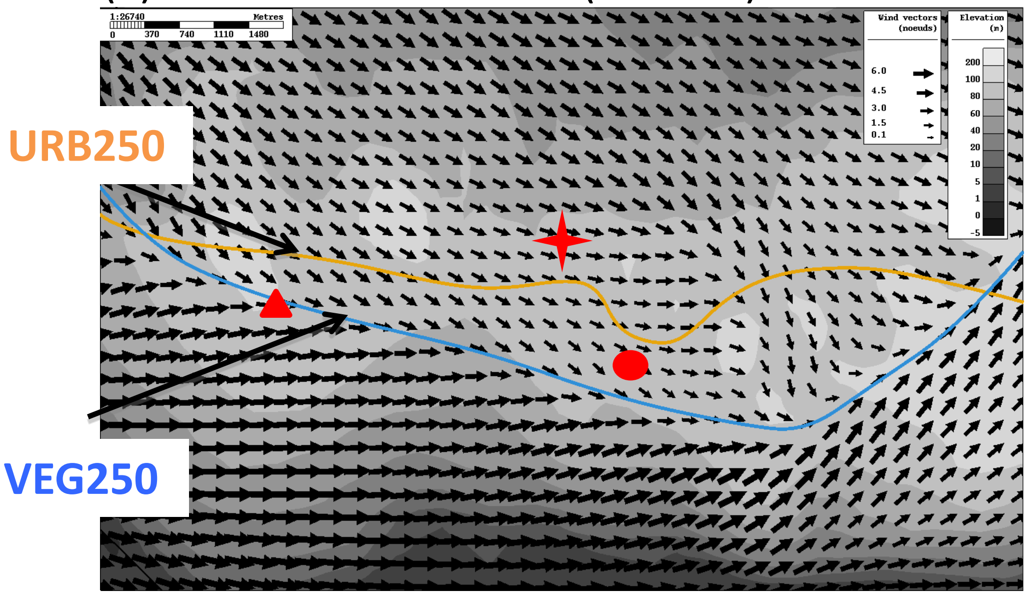


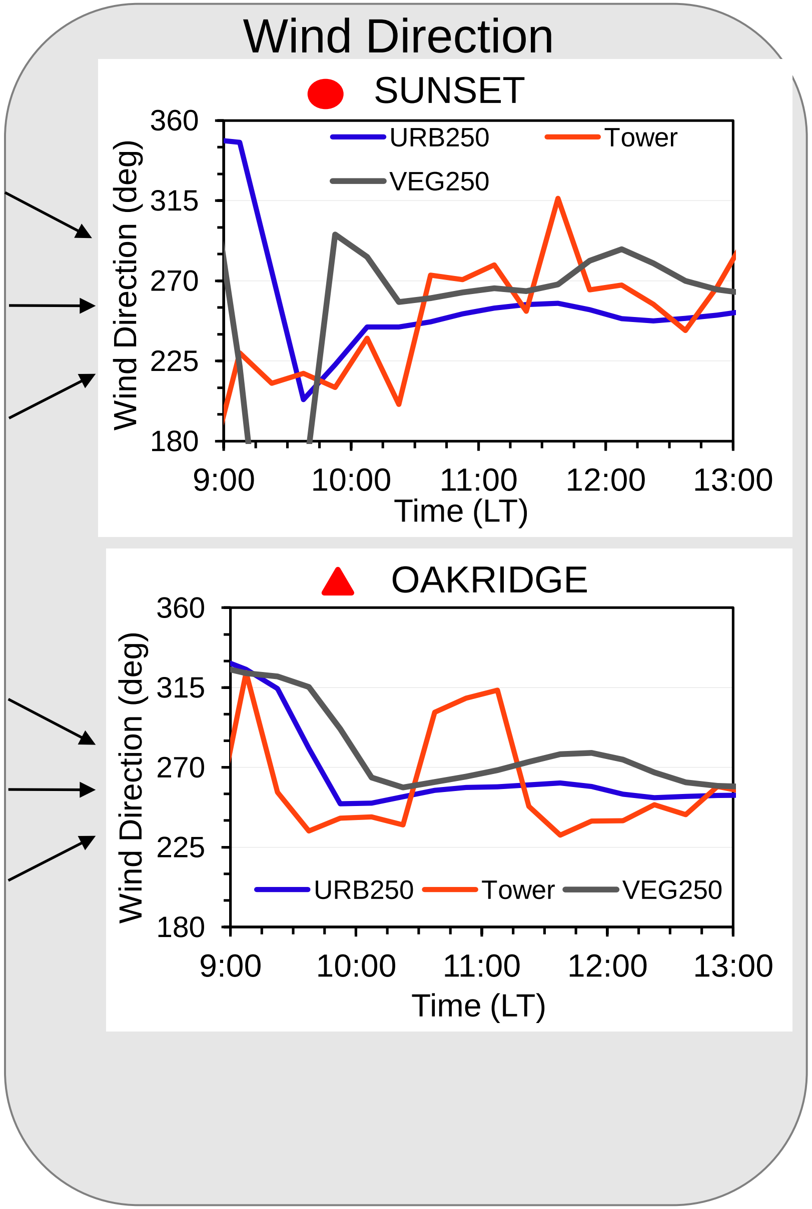


- Morning deepening of the Mixed Layer height
- Drops observed – subsidence

Influence of the urban area on the Convergence Lines

(a) URB250 and VEG250 (1000 LT)





Importance of for

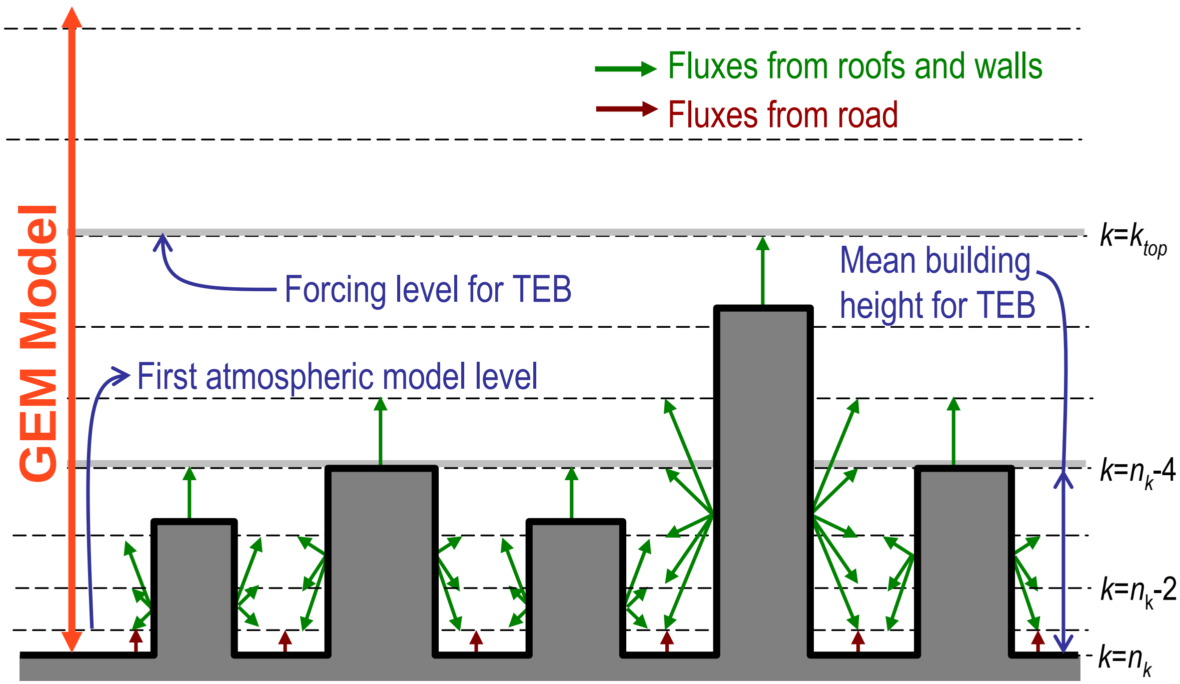
Research : Multi-Level Coupling (Urban Canopy)

- CaM-TEB (Canadian Multilayer version of TEB)

Features

- Several model levels intersect the buildings.

- Variable building heights exist within a grid cell.

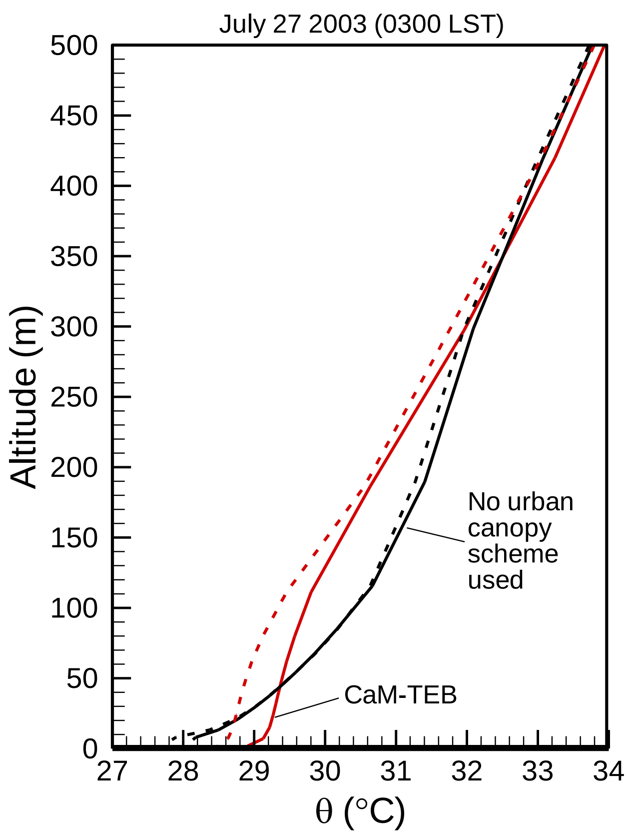


- TEB is used for canopy surface temperatures assuming:

  - No differential heating.
  - All roofs in a grid cell have equal temperatures.

(Husain et al. 2013)

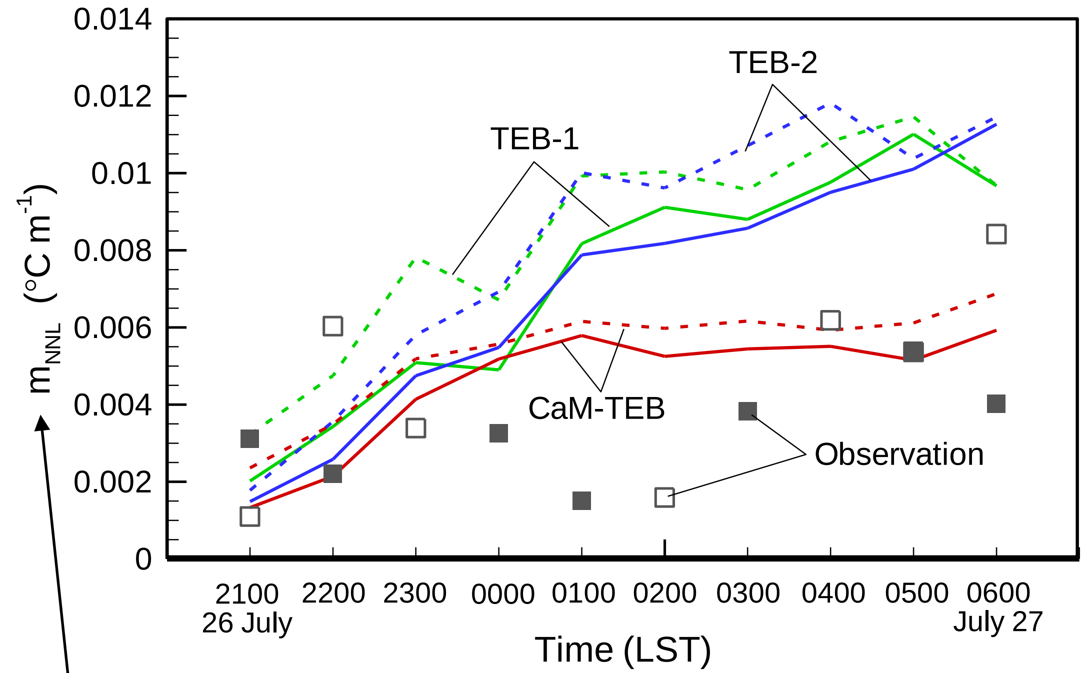
Improvement of the near-neutral layer forecasting with CaM-TEB in Oklahoma City (Joint Urban 2003)



Canadian Multilayer version of TEB,

Husain et al 2013a, 2013b

Here, runs with 1 km grid spacing



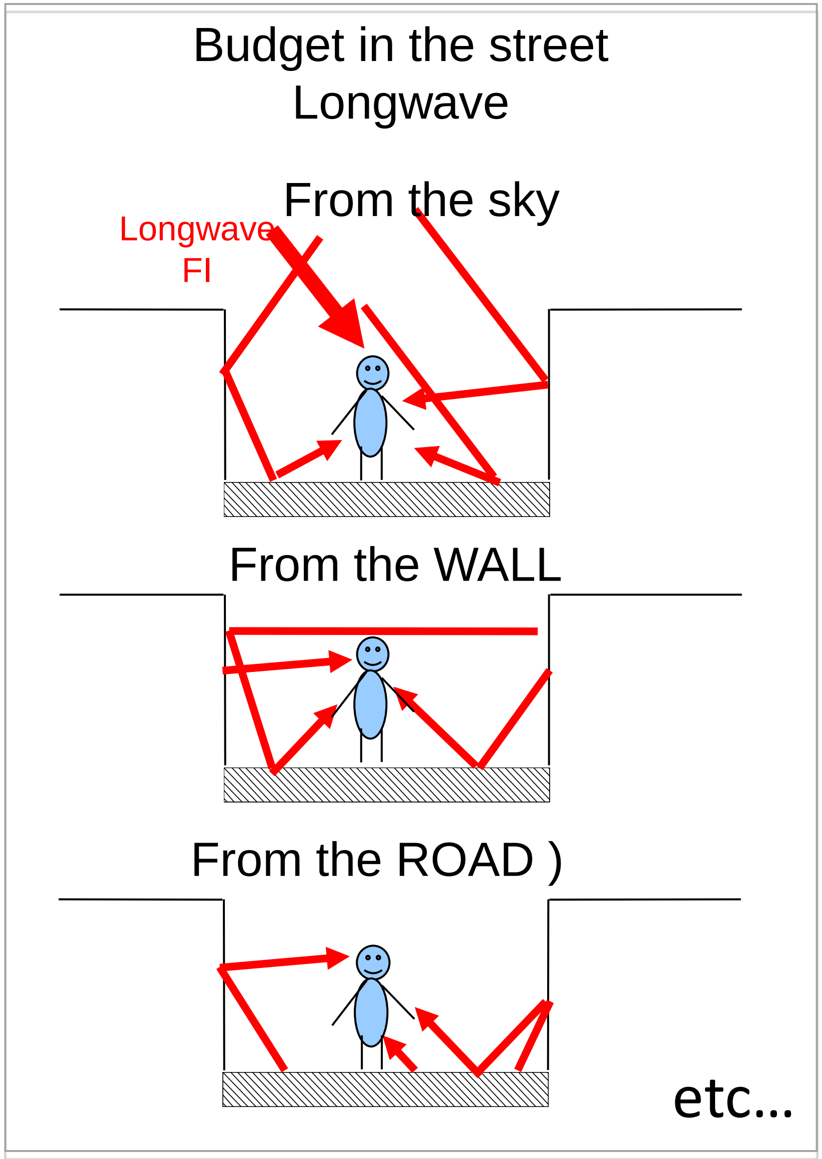
Slope of temperature gradient

Developments : Heat Stress Indices in NWP systems

Main external factors influencing the human body

•Air temperature *(ok)*
•Air humidity *(ok)*
•Wind velocity *(ok)*
•Radiations
—> mean radiant temperature

Radiative budget takes into account multiple reflexions



Conclusions

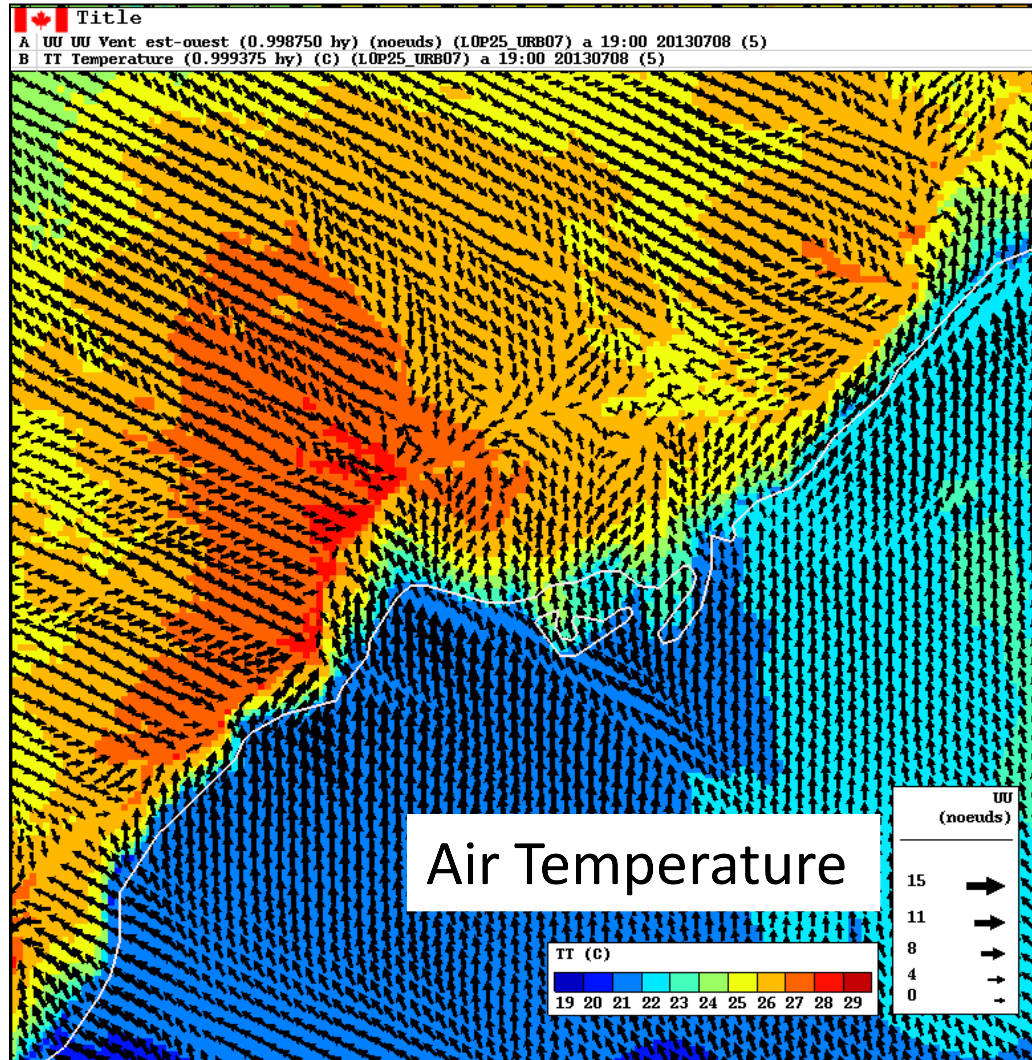
- Numerical Runs going on over the region of Toronto

- Current optimizations and development of the Integrated system

- Case studies:
    - Extreme weather
    - 8 July 2013
      (… Very complex case: not only urban)

    - Plan to run Heat Waves events
      (test of thermal indices)

Lake breeze at 10-m AGL
(250 m grid spacing)



Thanks for your attention !

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