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High-Resolution Numerical Simulations over the Complex Urban Area of Vancouver, Canada

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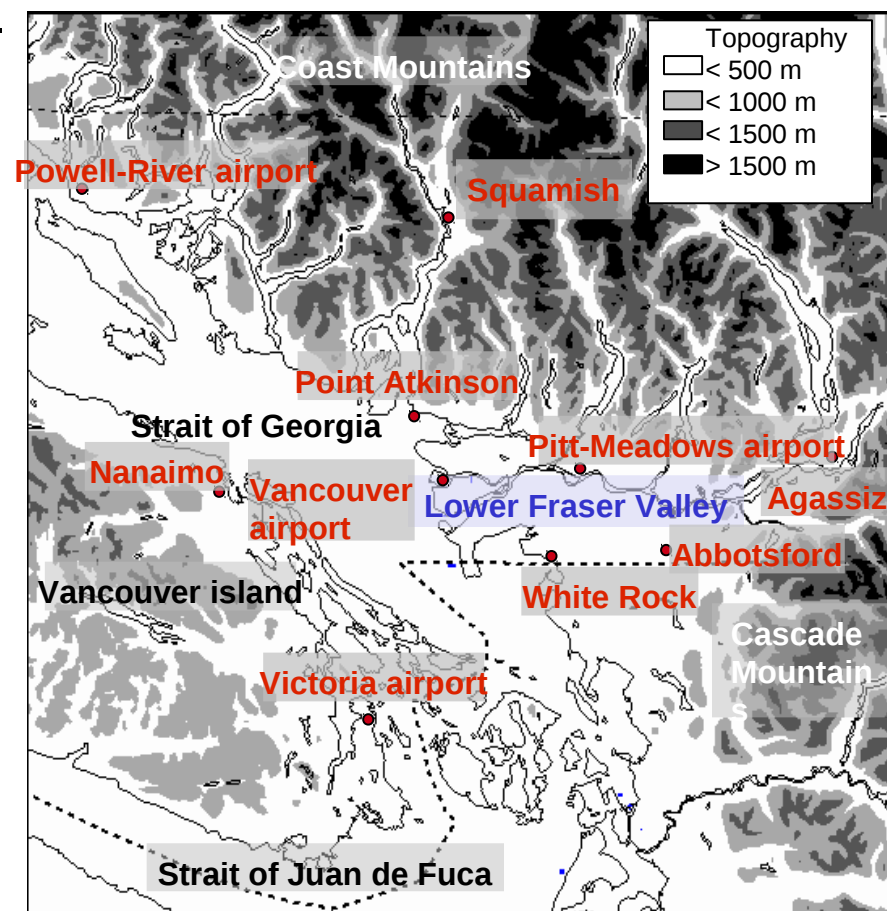
Environment Canada

ASI – The Atmospheric System and its Interactions, Environmental Meteorology

EMS Annual Meeting, Berlin, Germany, 15 Sept. 2011

Background

- Vancouver : Sprawled city but smart-growth (densification)
- Complex geography
- Meteorology influenced by local phenomenon
- Upper layers of pollutants
(McKendry and Lundgren 2000)
- Numerical studies : difficulties to simulate correctly the sea and slope winds
- **What about the influence of the urban area in this region ?**
- EPICC observational network (2007-2010)



● Environment Canada permanent weather stations



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EPiCC network in Vancouver

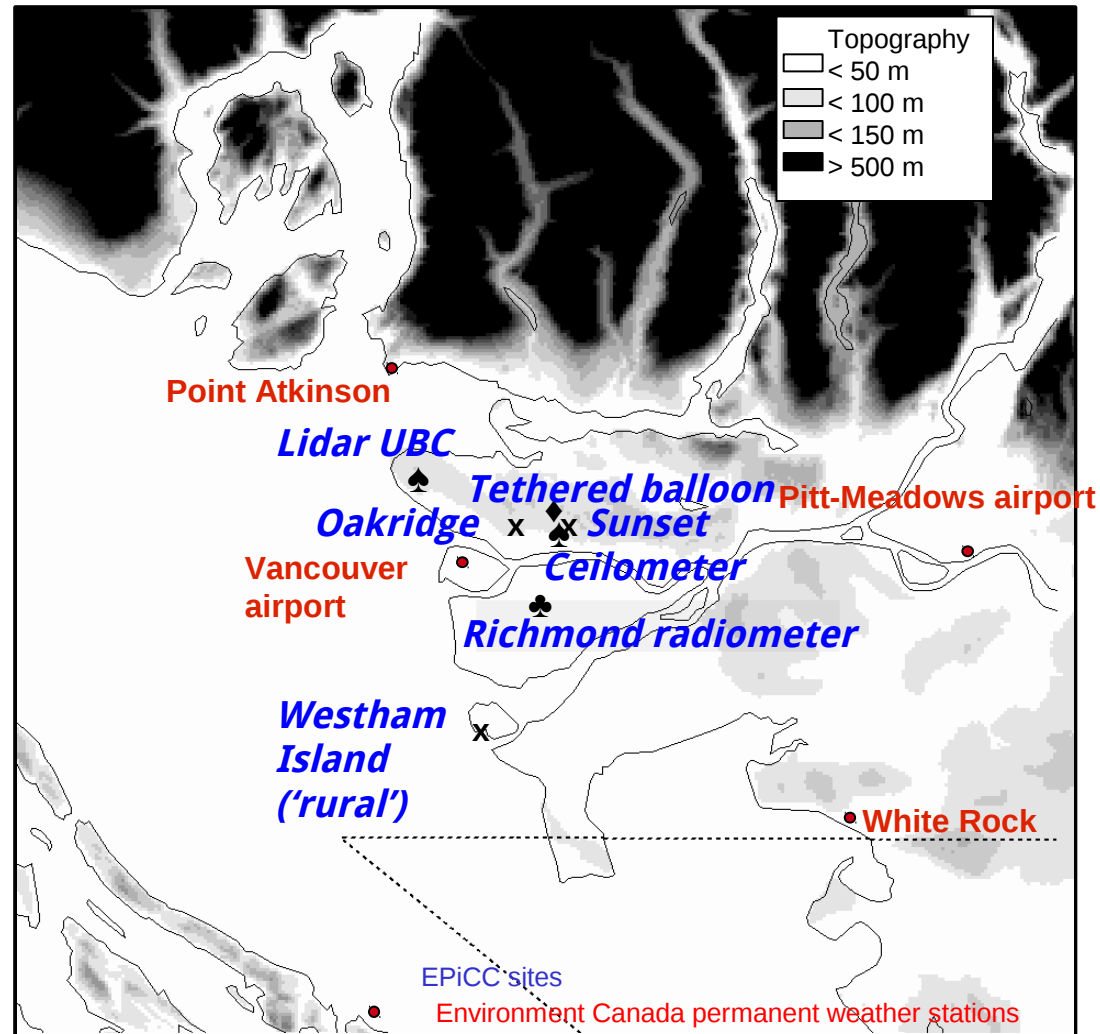
Available data for 14-15 August 2008

SURFACE :

- 3 Towers
- Meteo - turbulent fluxes (29 m -3 m)

BOUNDARY LAYER :

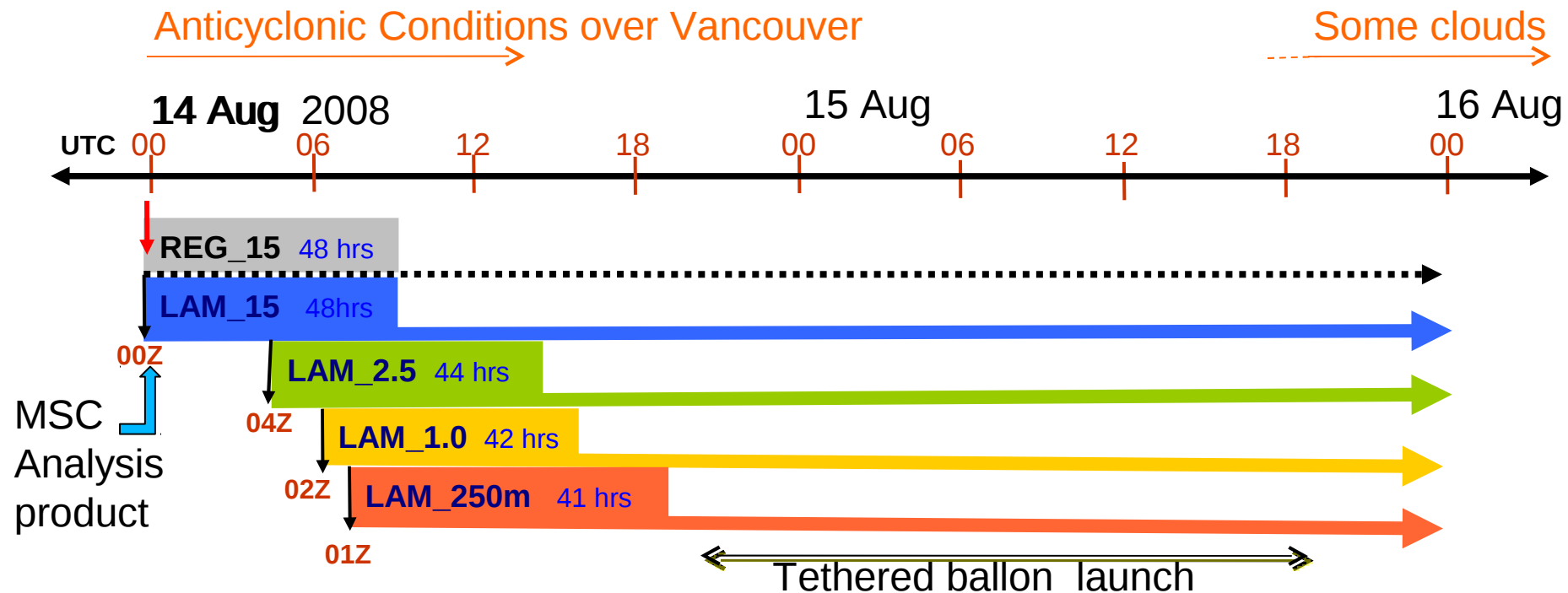
- Tethered balloon : T, q, u, v (0-500 m)
- Ceilometer : BLH
- Lidar : BLH
- Radiometer : T, q vertical profiles (0-5 km)



Data from the Vancouver EPiCC network <http://www.epicc.uwo.ca>

A. Christen, B. Crawford, I. McKendry, D. Von Der Kamp

Duration of the multi-resolution cascade (model GEM)



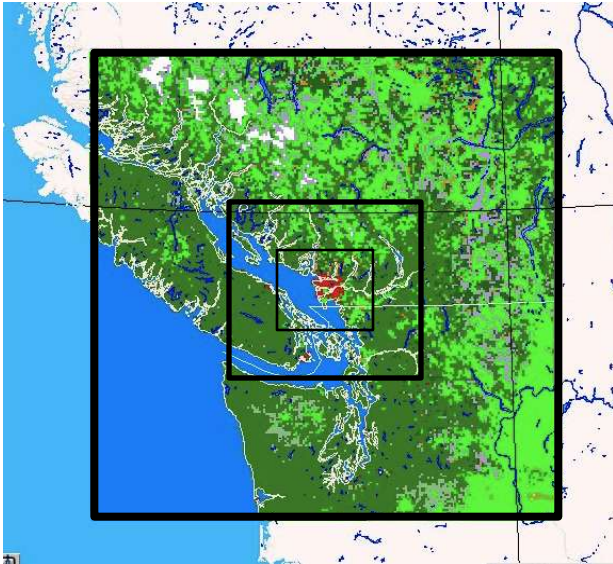
Resolution	15km	2.5km	1km	250m
Urban scheme	-	TEB*	TEB*	TEB*
Land scheme	ISBA ⁺	ISBA ⁺	ISBA ⁺	ISBA ⁺
Timestep	450 s	60 s	30 s	10 s
First level (u)	~ 40 m	~ 10 m	~ 10 m	~ 10 m
Nb of levels	58	55	55	55
Levels <1500m	10	25	25	25

* **TEB**: Masson (2000), Lemonsu et al. (2004), Leroyer et al. (2010)

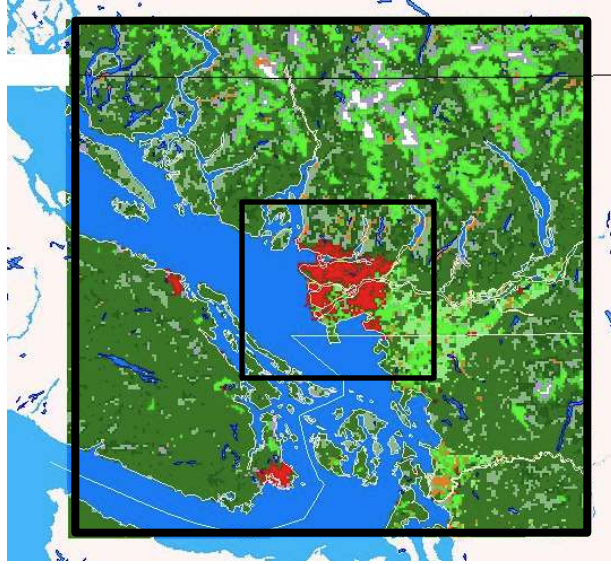
+ **ISBA**: Noihlan and Planton (1989), Bélair et al. (2003)

Land surface characteristics

2.5 km

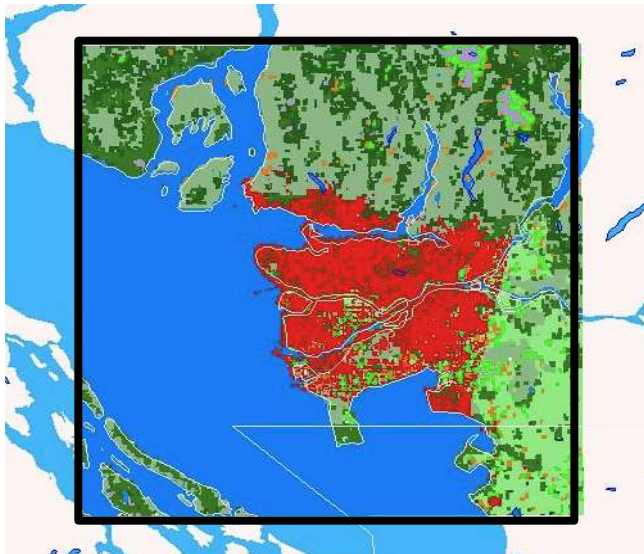


1 km



- Data from Globcover (resolution 200 m)

250 m



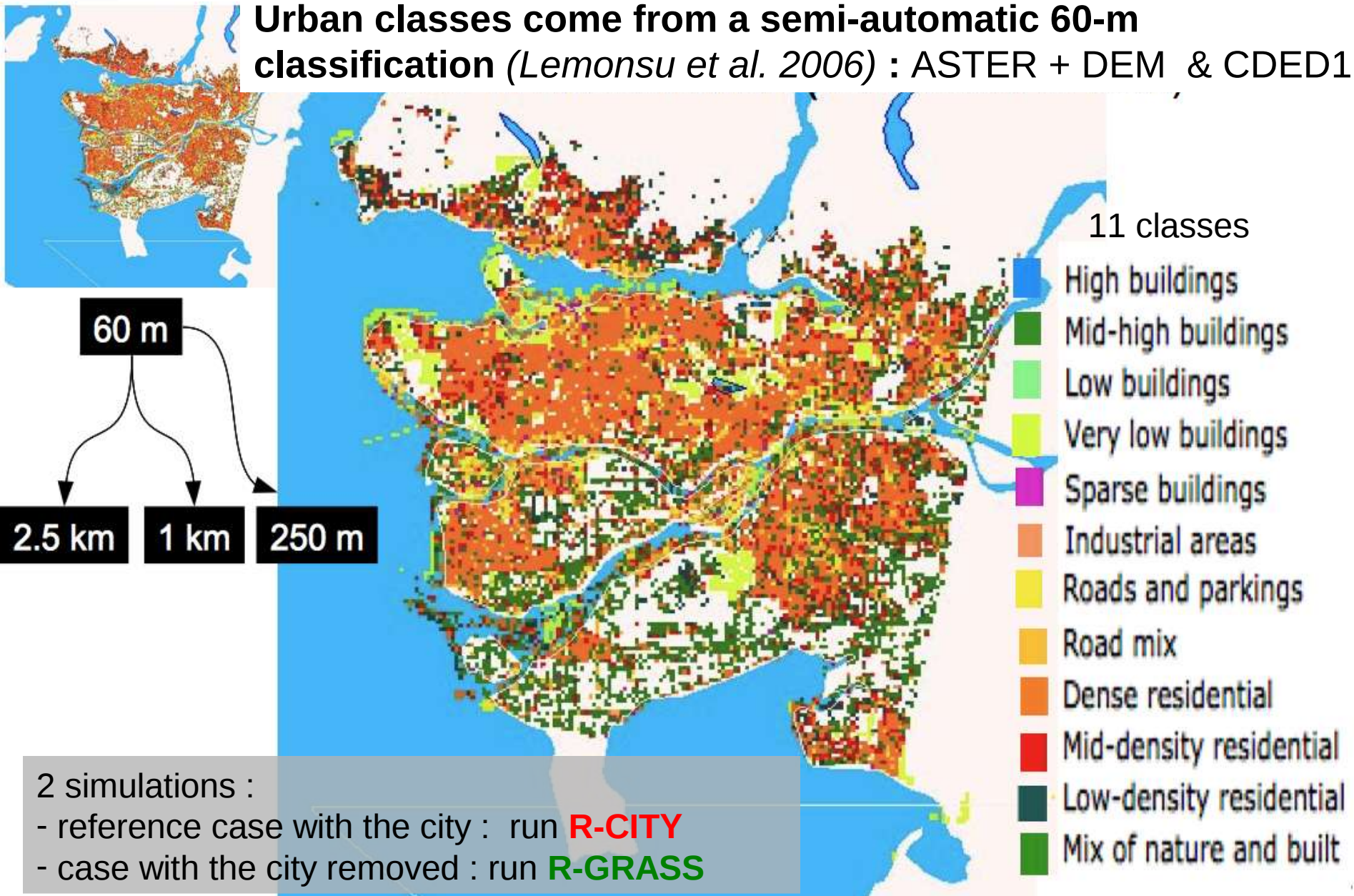
Land Use & Land Cover

- water
- ice
- evergreen needleleaf trees
- deciduous needleleaf trees
- deciduous broadleaf trees
- mixed shrubs
- mixed wood forest
- crops
- long grass
- tundra
- urban

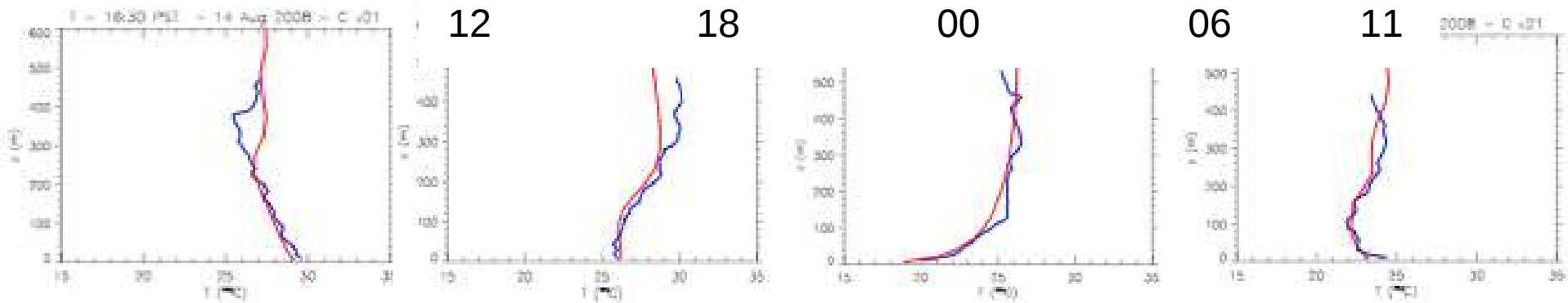
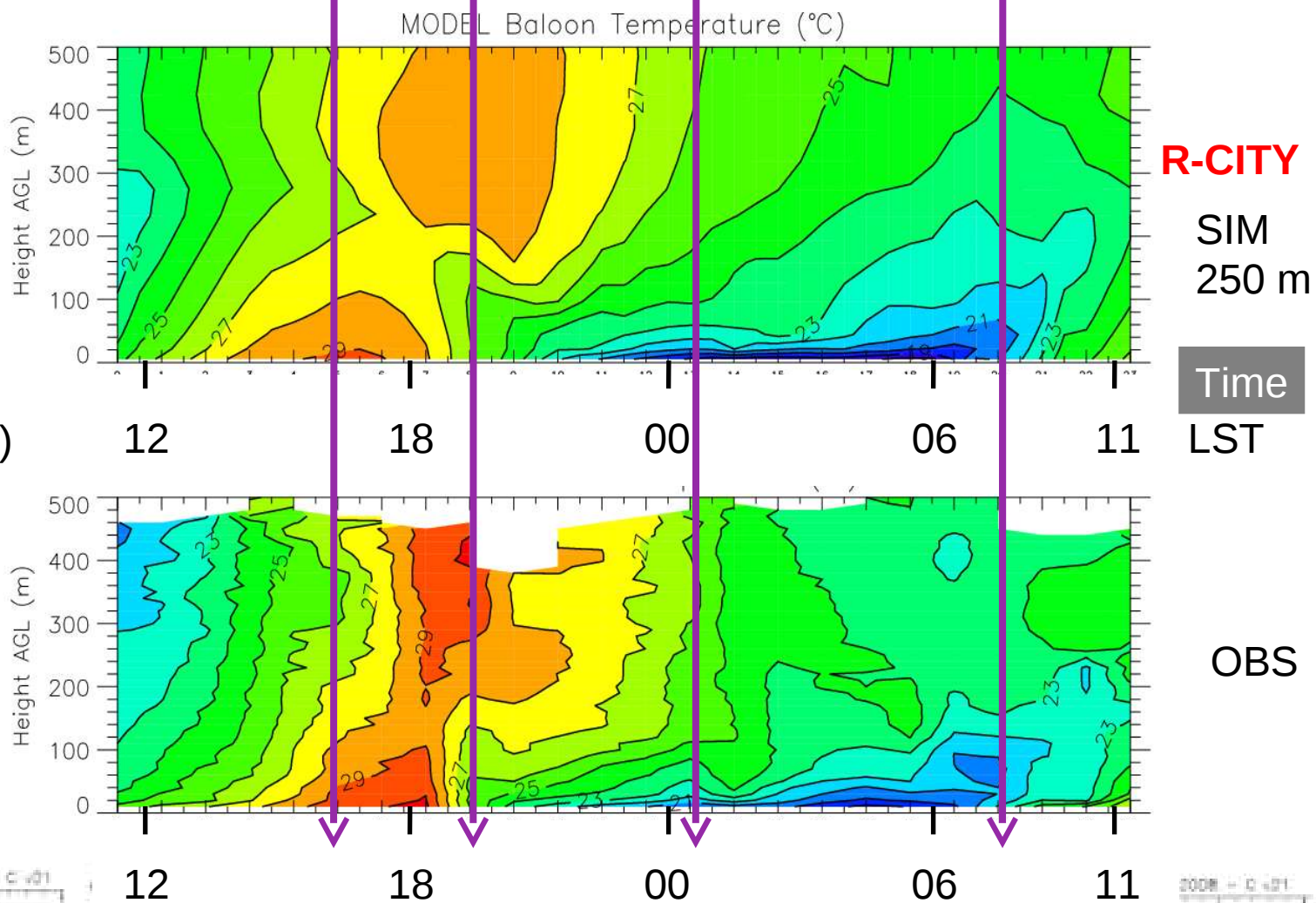
- 26 classes in ISBA

Urban area characteristics

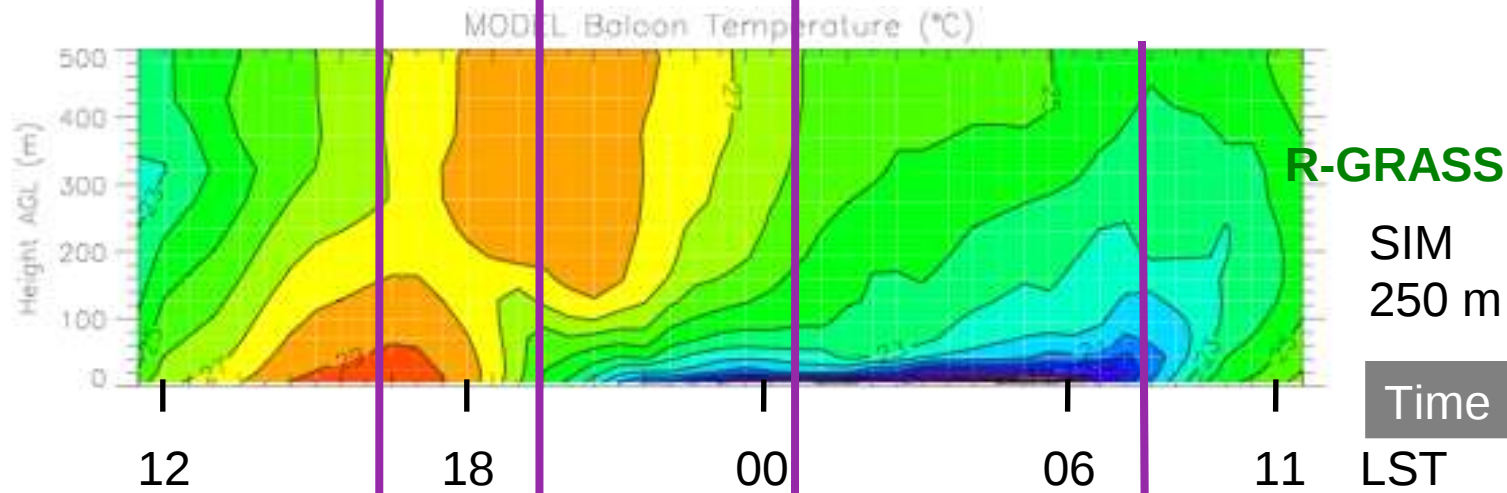
Urban classes come from a semi-automatic 60-m classification (*Lemonsu et al. 2006*) : ASTER + DEM & CDED1



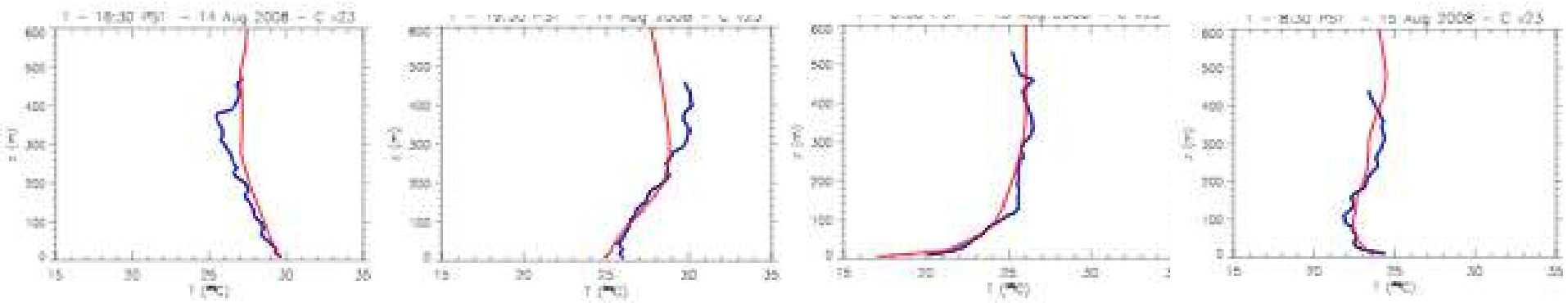
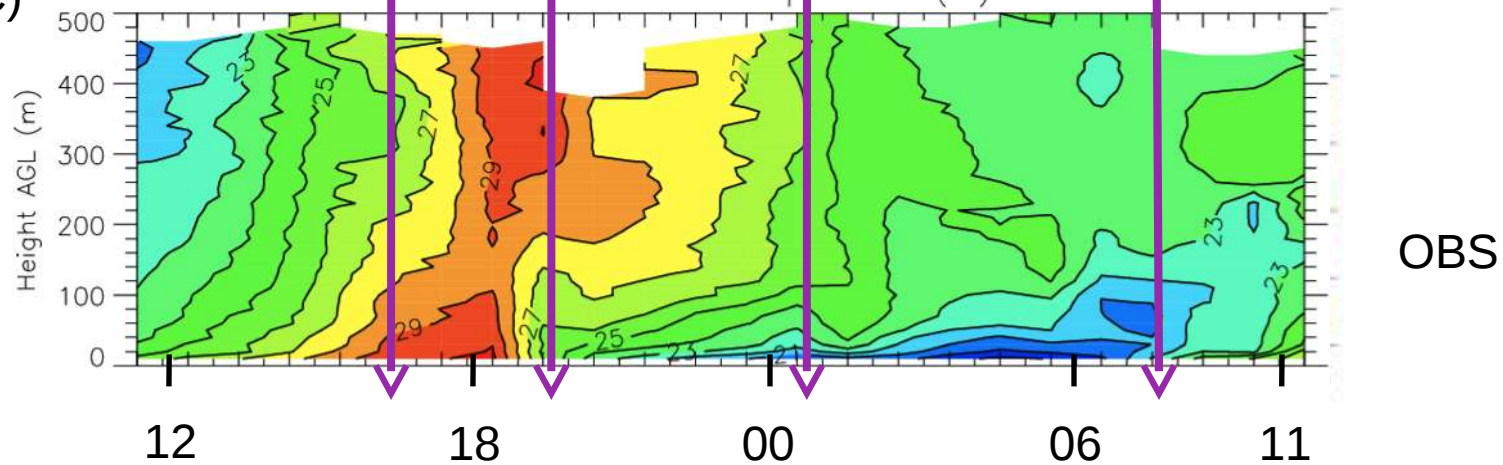
Comparison with boundary Layer observations – Tethered balloon

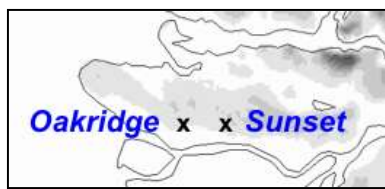


Comparison with boundary Layer observations – Tethered balloon



Temperature (C)





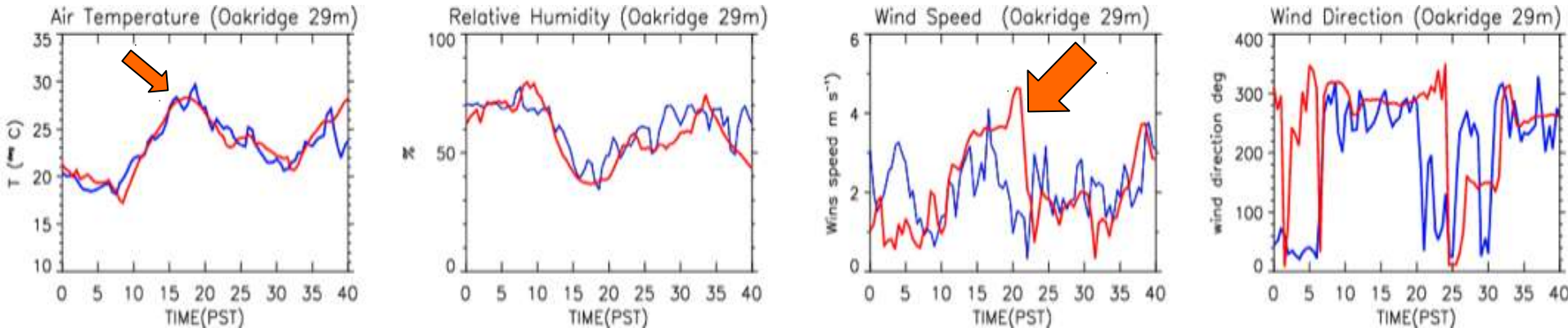
Comparison with surface observations EPICC urban tower sites (29 m) AGL



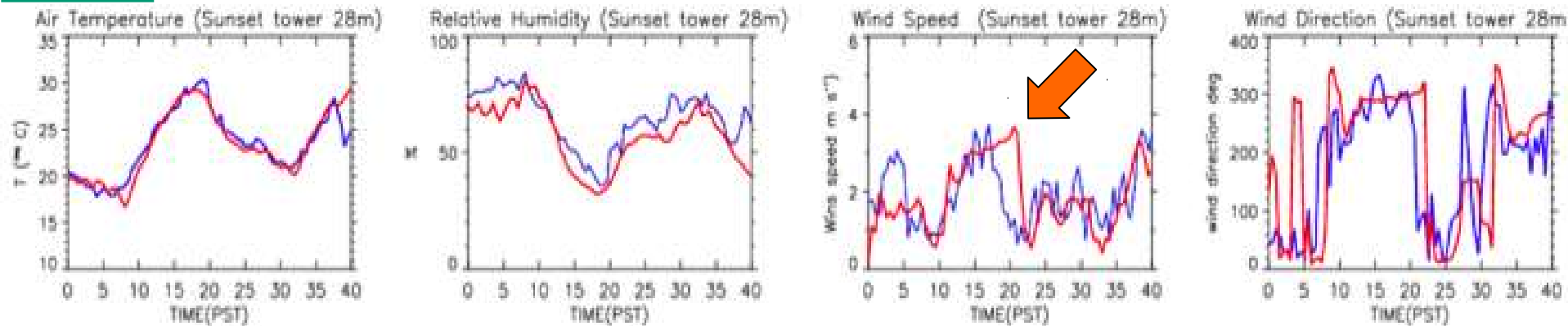
OBS
MODEL

RUN 'R-CITY'

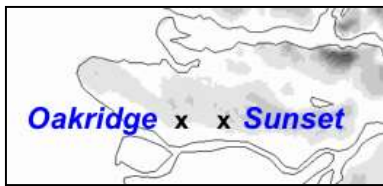
Oakridge



Sunset



- Meteorological variables well simulated, except for the late afternoon wind (land breeze establishment).
- Observations exhibit daytime oscillations ? Or ?



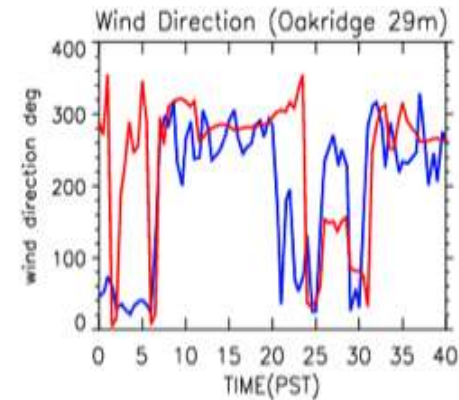
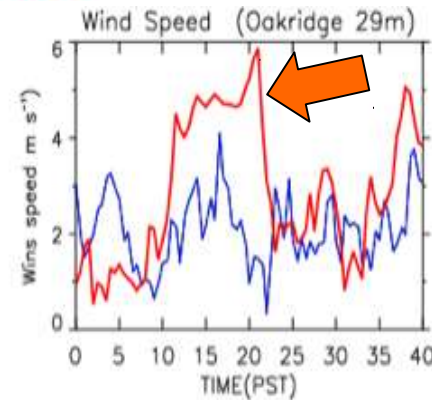
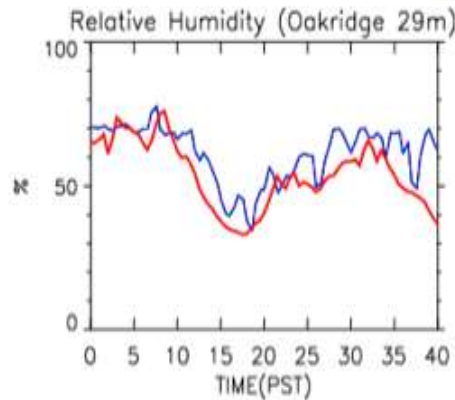
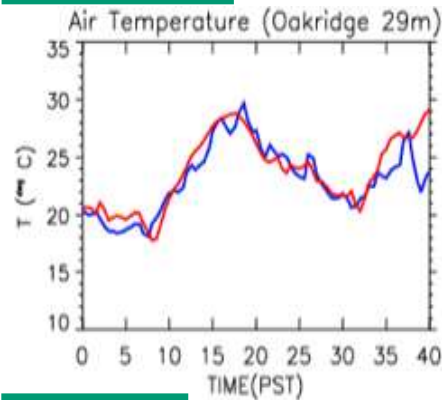
Comparison with surface observations

What is the impact of the urban area ?

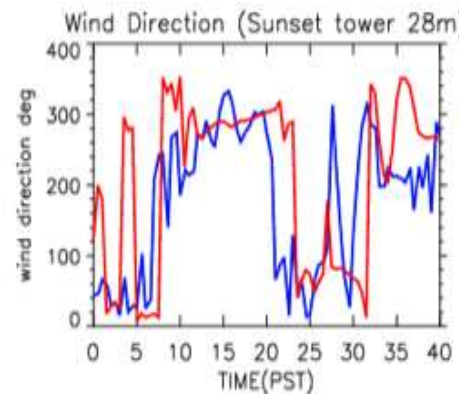
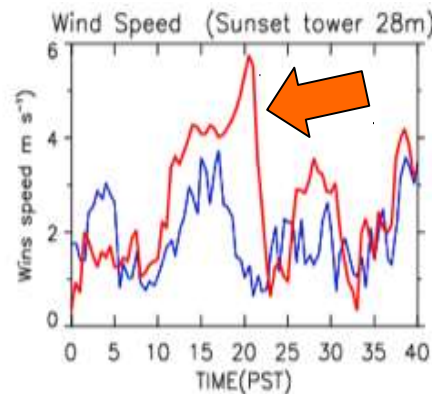
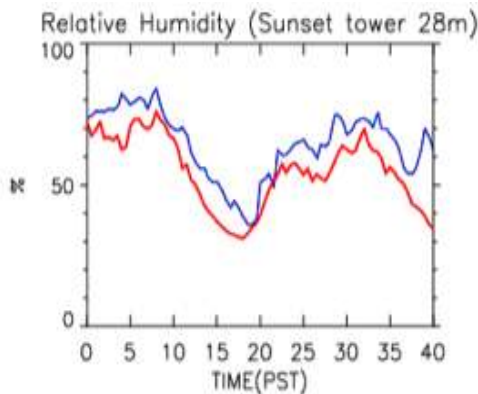
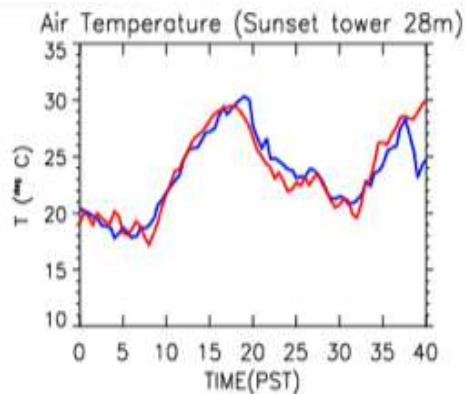
OBS
MODEL

RUN 'R-GRASS'

Oakridge



Sunset

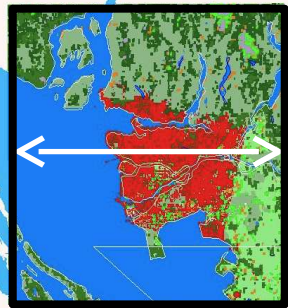


- City acts to reduce the sea-breeze wind intensity
- late afternoon peak in this case appears on the 2 sites
- modest effect on temperature and humidity

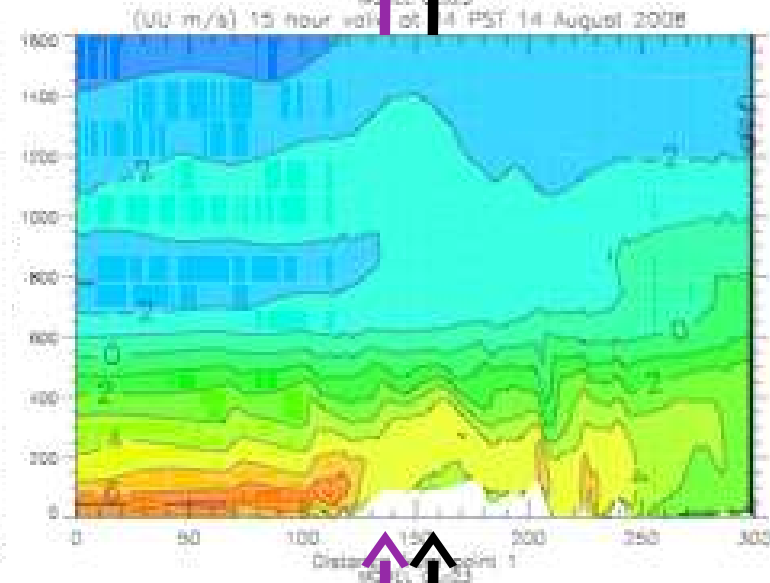
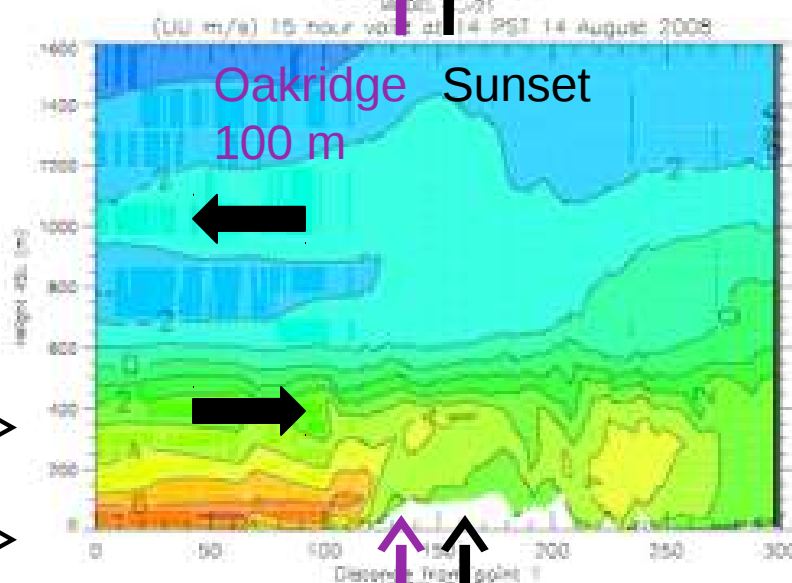
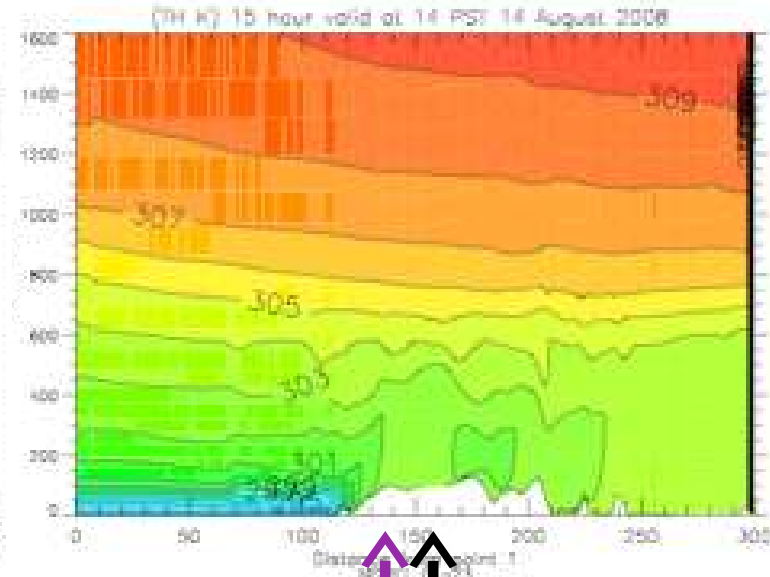
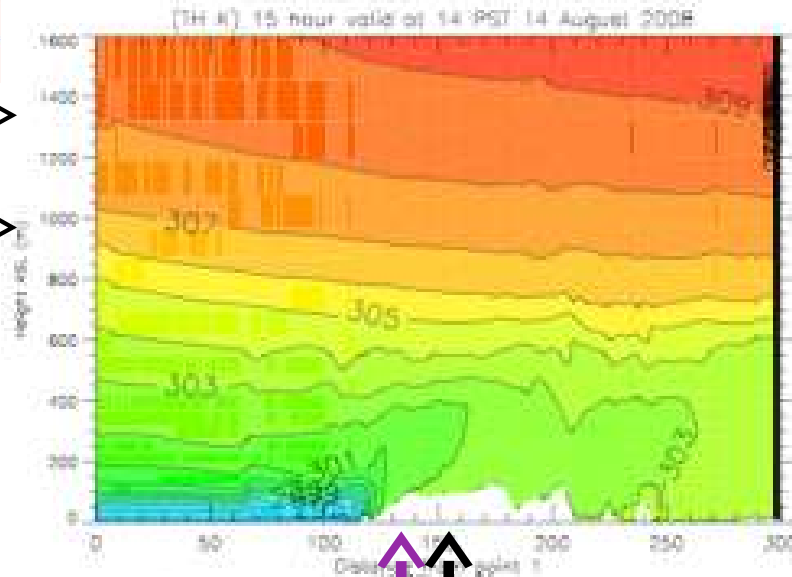
Development of the sea-breeze Vertical section (1400 PST)

R-CITY

R-GRASS



Potential
temperature



- over the city : more mixing & lower wind speed
- Strong jet from the strait of Georgia

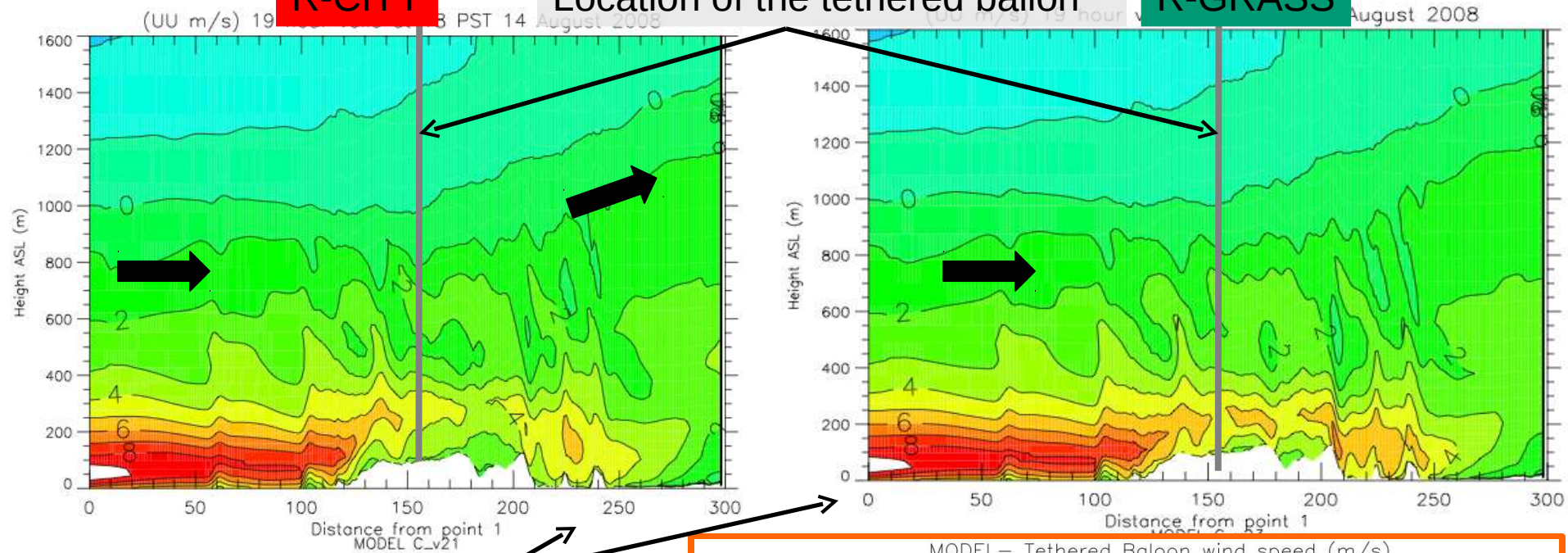
Longitudinal
wind velocity

R-CITY

Location of the tethered balloon

R-GRASS

August 2008



Conclusions

urban GEM-LAM cascade from 15km, 2.5 km, 1 km, to 250m applied over the Vancouver metropolitan area during a sea-breeze event :

- Urban model allows to better reproduce near-surface atmospheric structure, and the diurnal cycle of meteorological variables diurnal cycle
- The city of Vancouver tends to slow down the sea-breeze flow, at the surface, and up to about 400-500 m

However,

- Conclusions are dependent on the simulation where the city is removed (replaced by ... ?)
- Low-level jet in the sea-breeze flow seems to be overpredicted
- The necessity to use very-high resolution is not proven in this case

Thanks for your attention !