ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

European Research Council
Executive Agency

Intercomparison of radiative fluxes in the SURFEX TEB and observations from a moving platform in the streets of Helsinki

Carl Fortelius, Achim Drebs

33rd EWGLAM and 18th SRNWP meetings

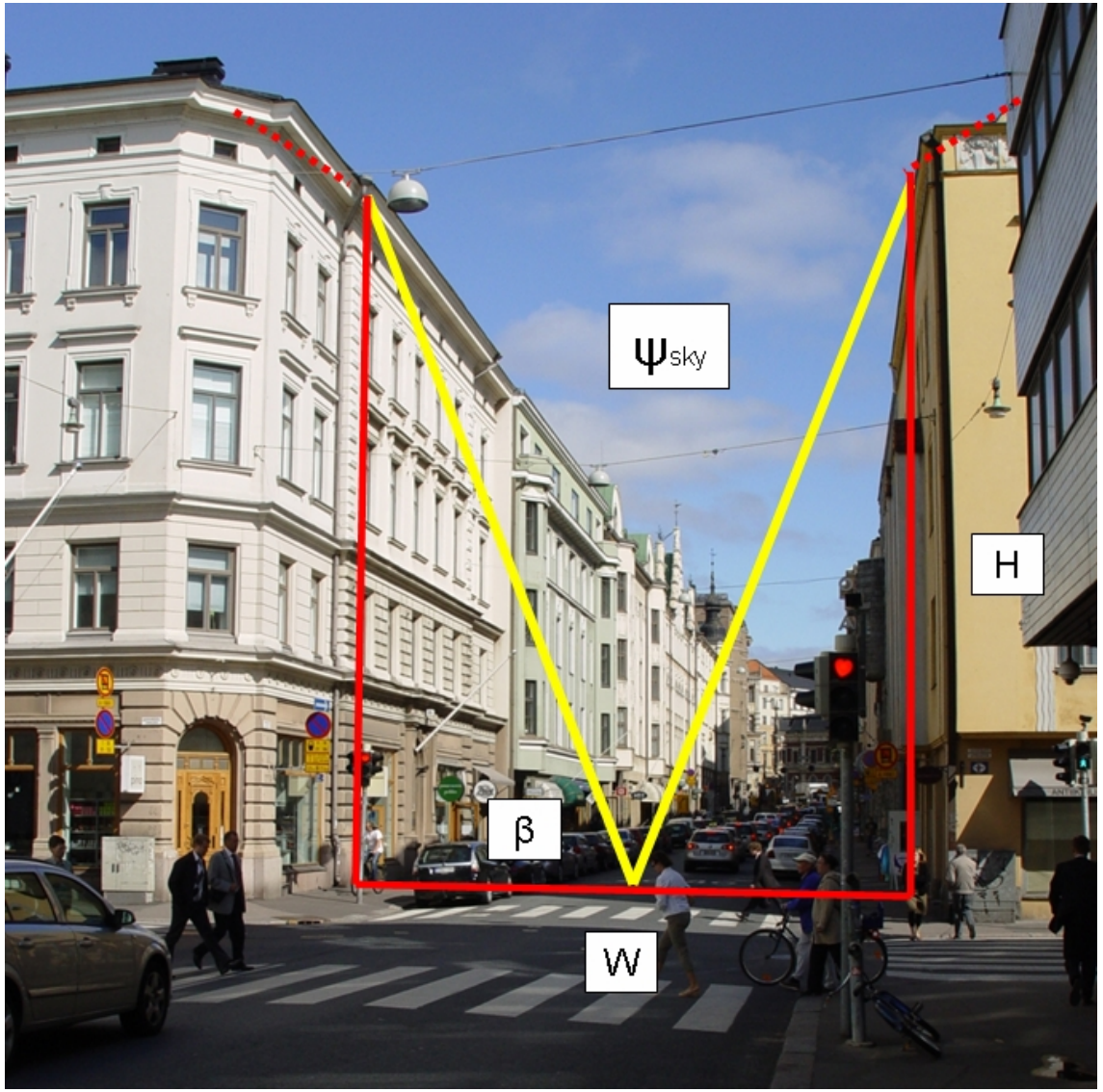
Tallinn, 10-13 October 2011

Contents

- **Helsinki facts**
- **The Helsinki street campaign**
- **The Town energy balance model (TEB)**
- **Results**
  - Model vs data
  - Sensitivity to urban characteristics
- **Conclusions**

Central Helsinki in a nutshell

- On the coast, 60.2 N, 25.9 E
- Minor orographic variations
- Population: 600 000, 1 M in Helsinki metropolitan area
- Fairly closed streets
- Building height 20-30 m
- Mostly built in the early 20th century
- brick, concrete, steel frame
- street surfaces mostly asphalt and granite setts
- Photo: Uudenmaankatu, Achim Drebs

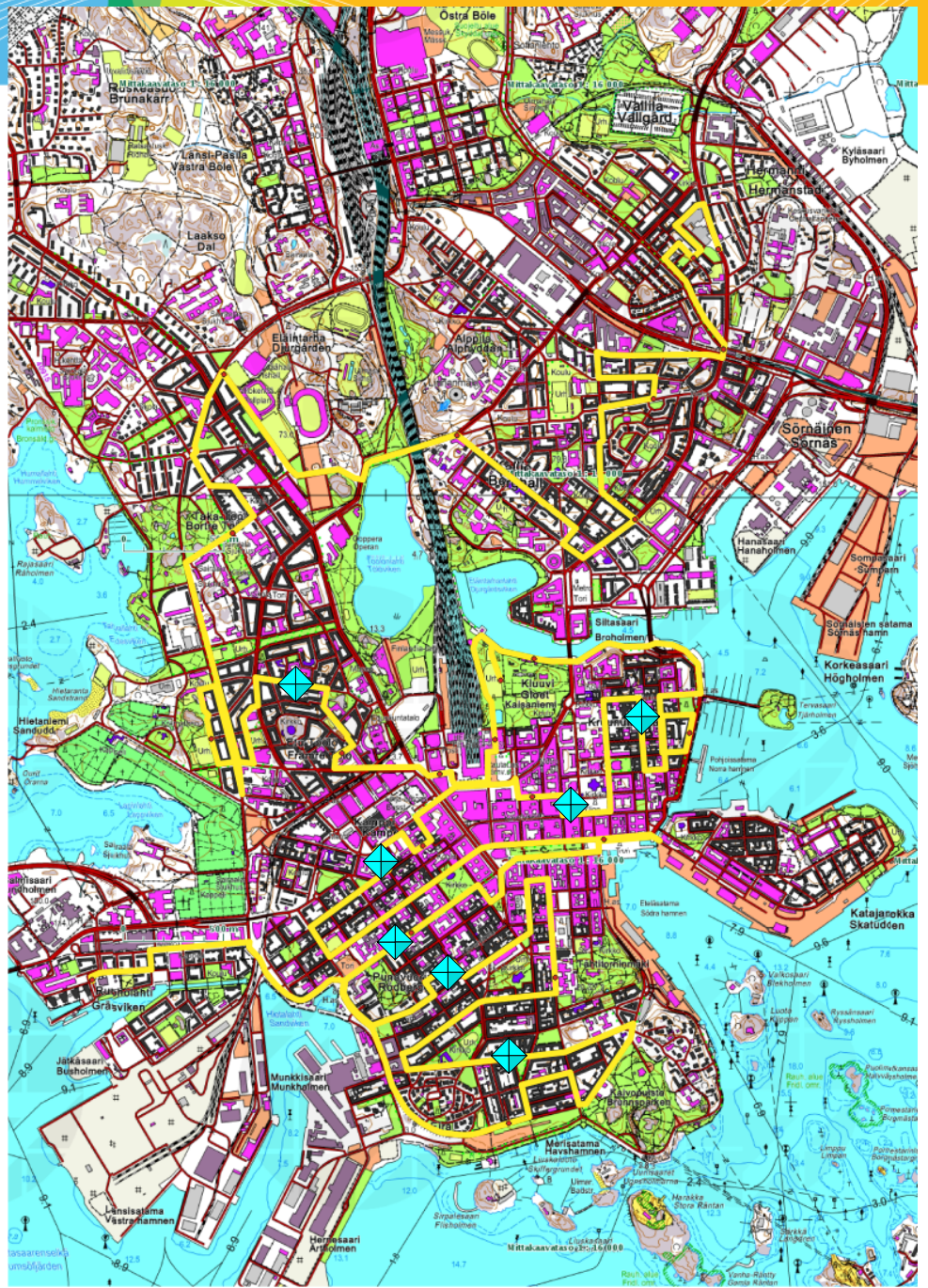


ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Mobile soundings:

Achim Drebs at his instrumented VW transporter

- T, (T_{wet}), SWD, SWU, LWD, LWU
- Day (~09 UTC) and night (~21 UTC) **every Tuesday July 2009- June 2010**
- along yellow line
- used locations: ◈



Town Energy Balance model, conceptually

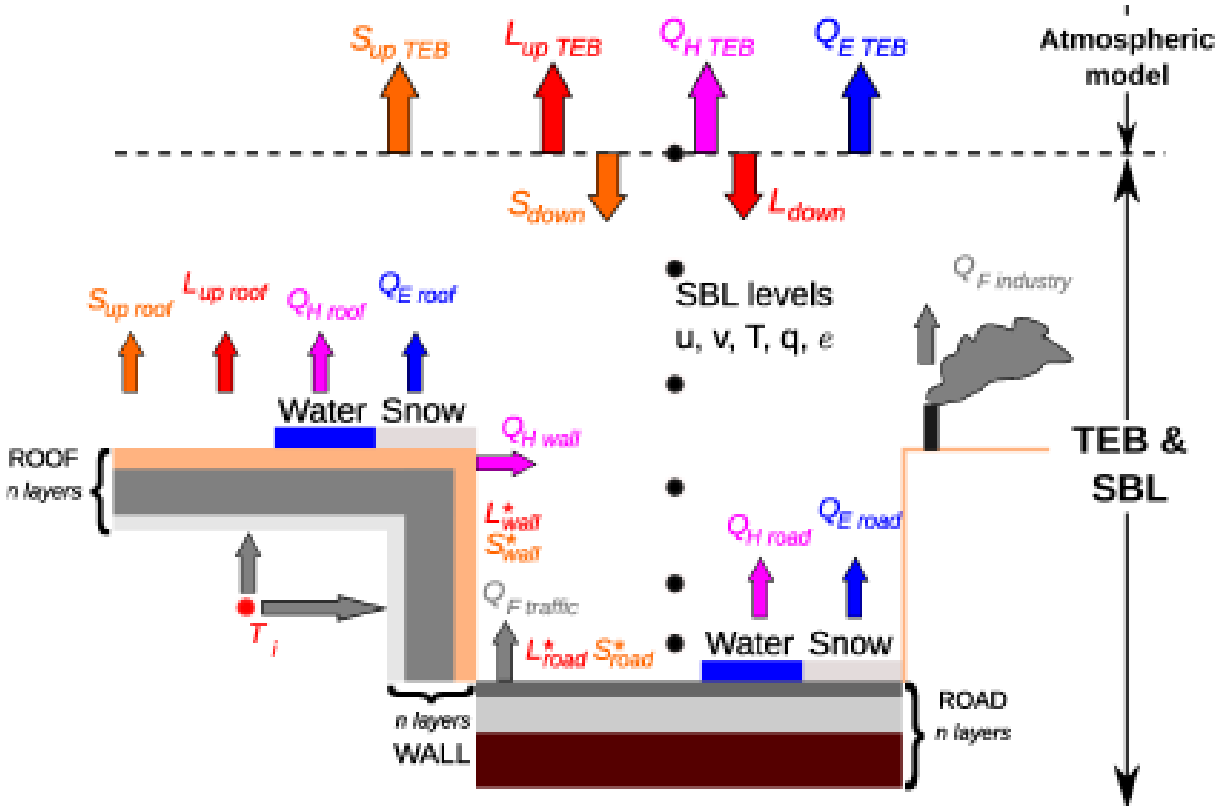


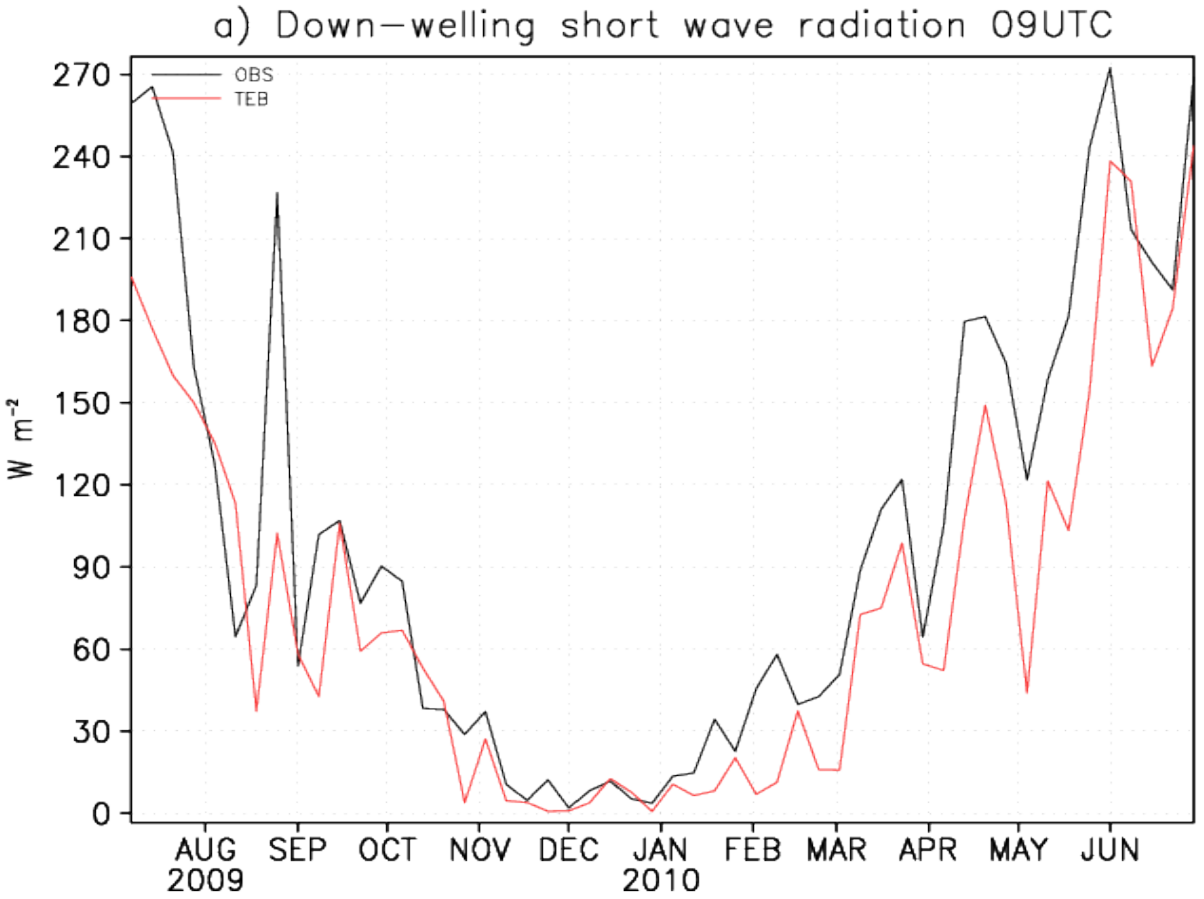
Figure 2: Schematic representation of the generic urban canyon used in TEB.
Source: www.cnrm.meteo.fr/vurca/IMG/pdf/teb_surfex_overview.pdf

Data and experiments

- **SURFEX v6.1**
  - Ensemble of 1D runs in off line mode, initiated 1 January 2009 and run for 2 years
  - Seven locations in central Helsinki: Bulevardi, Fredrikinkatu, Iso Robertinkatu, Kluuvikatu, Museokatu, Mariankatu,Tehtaankatu
  - Plus ”ECOCLIMAP” (cold suburban)
- **Atmospheric forcing (identical in all experiments):**
  - **ERA Interim**: *U, T, Q, Downwelling radiation, rainfall, snowfall, surface pressure*
    - *steps 03,06,09,12 h from runs at 00, 12 UTC, interpolated to 1.5 h*
    - *dx ~80 km*
- **Validation data:**
  - Mobile soundings of temperature and radiative fluxes, every Tuesday day and night July 2009 - June 2010

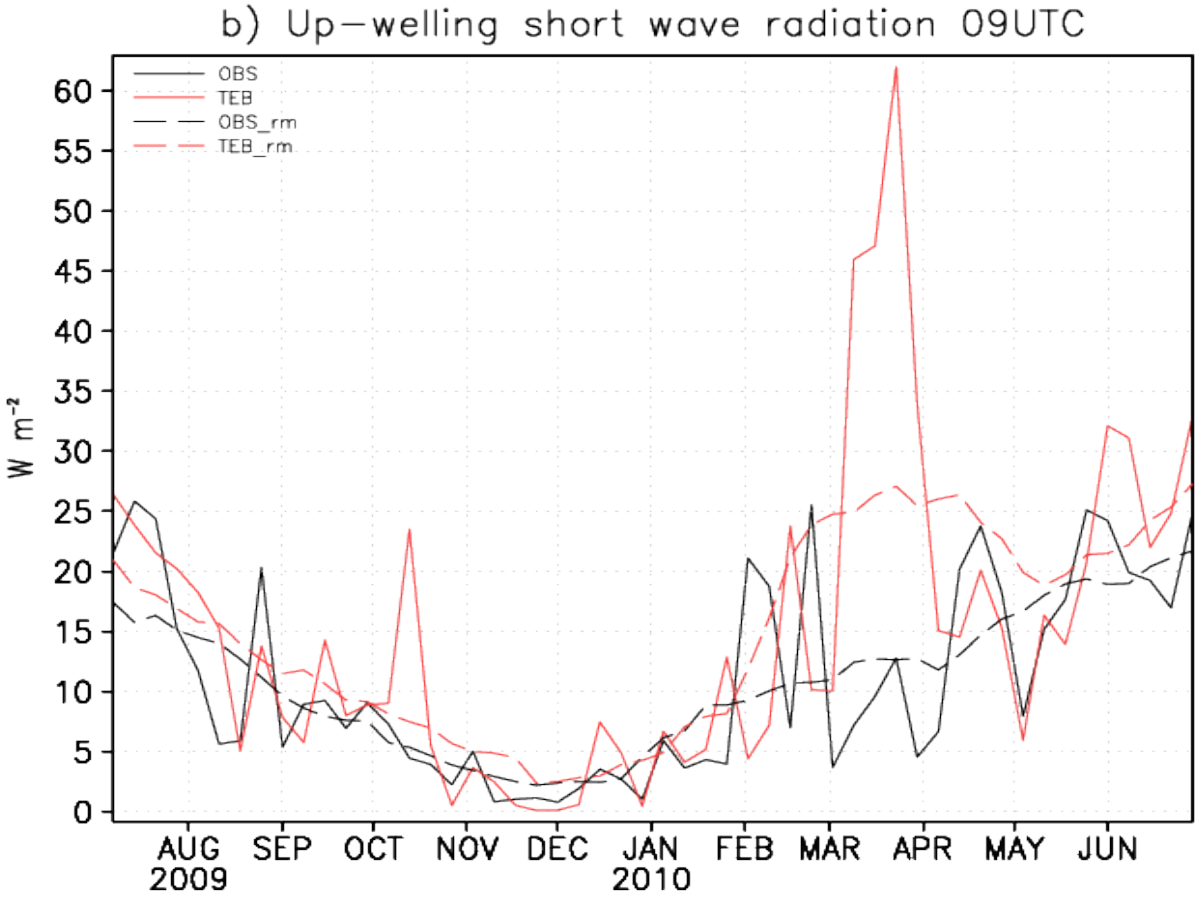
Ensemble averages: SWD

- controlled by the forcing (ERA) and by absorption and reflections from the wall and road surfaces
- positive correlation on annual-weekly time scales
- negative bias indicates too closed street canyons?



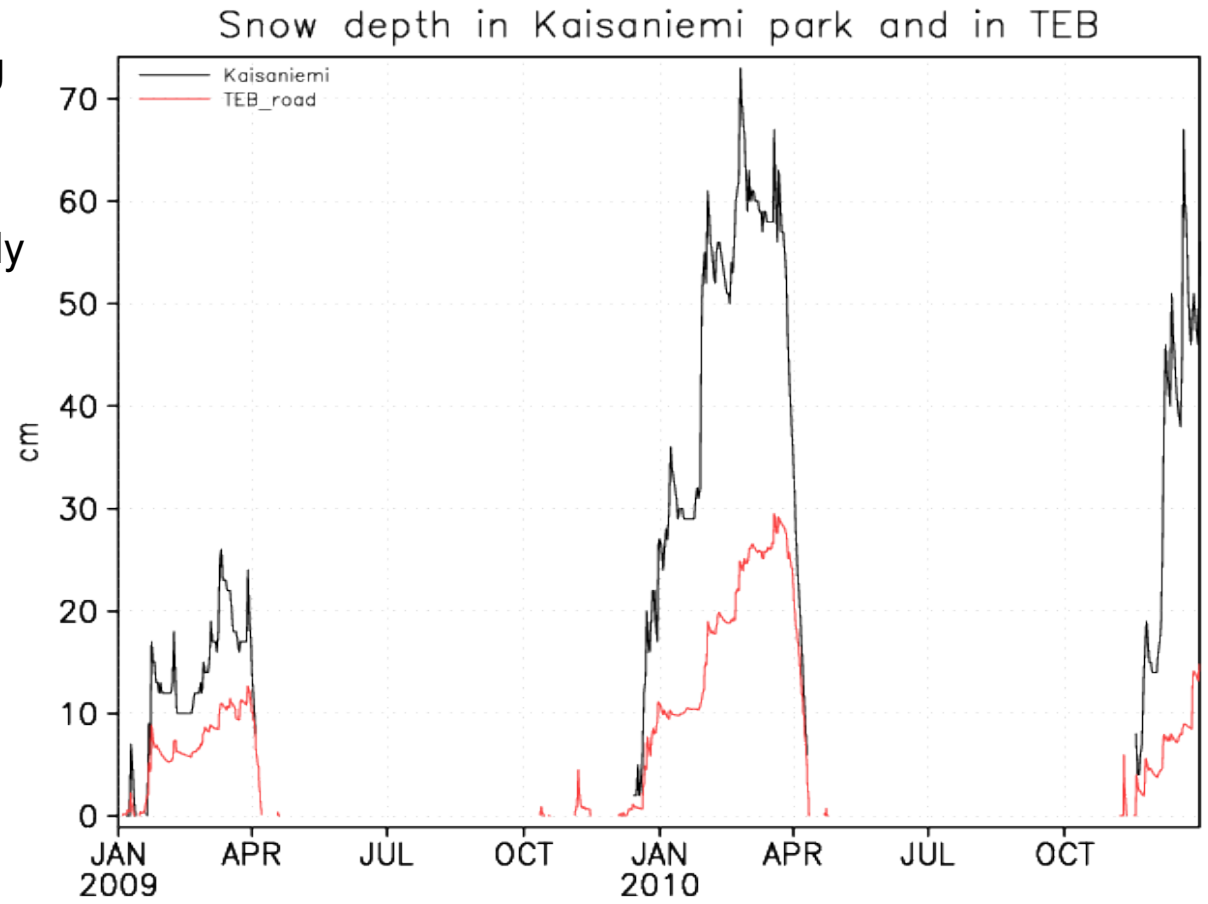
Ensemble averages: SWU

- controlled by SWD and reflection from the street surfaces (bare road and snow)
- positive bias in summer and autumn, dashed lines 11-week running mean (albedo 0.15, 0.10 for granite, asphalt, high?)
- spring time peak: lack of parameterized snow clearing



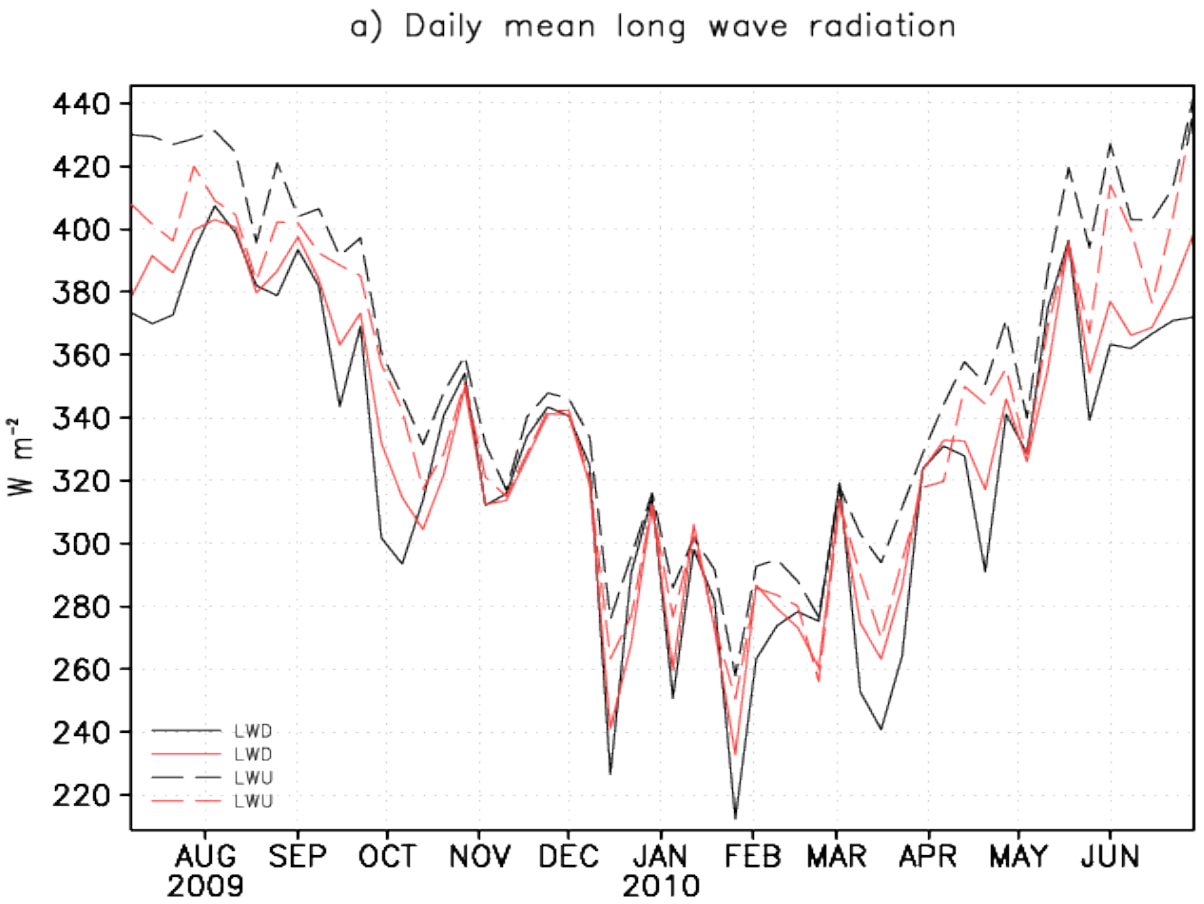
Snow depth

- TEB: Bright snow covering 70% of the road surfaces from January to April
- Actually, the snow is mostly removed from the streets and transported away



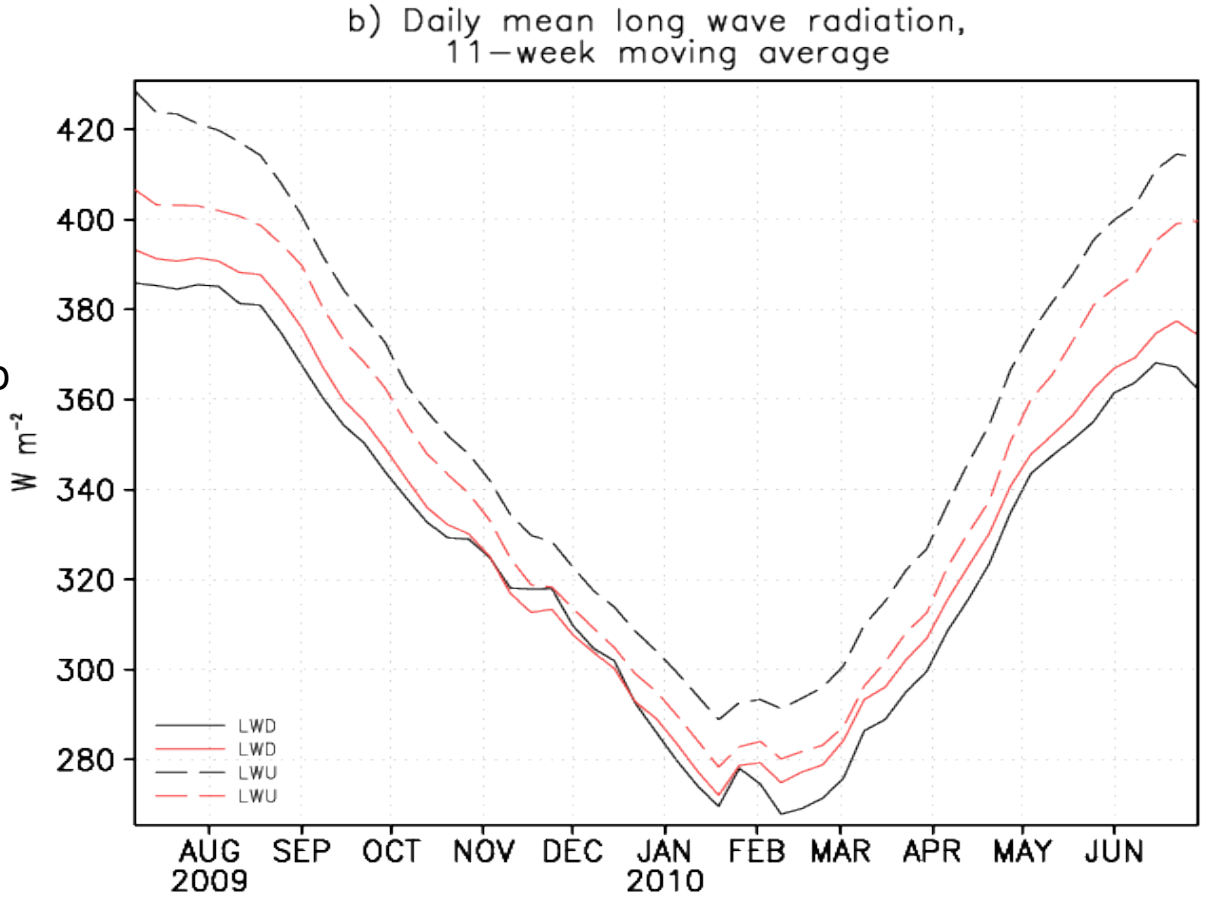
Ensemble averages: LWD and LWU

- LWD (solid) is controlled by the forcing, sky view factor, and emission from the walls
- LWU (dashed) is controlled by temperature and emissivity of the road surface and snow
- model fluxes correlate well with the measurements at all time scales



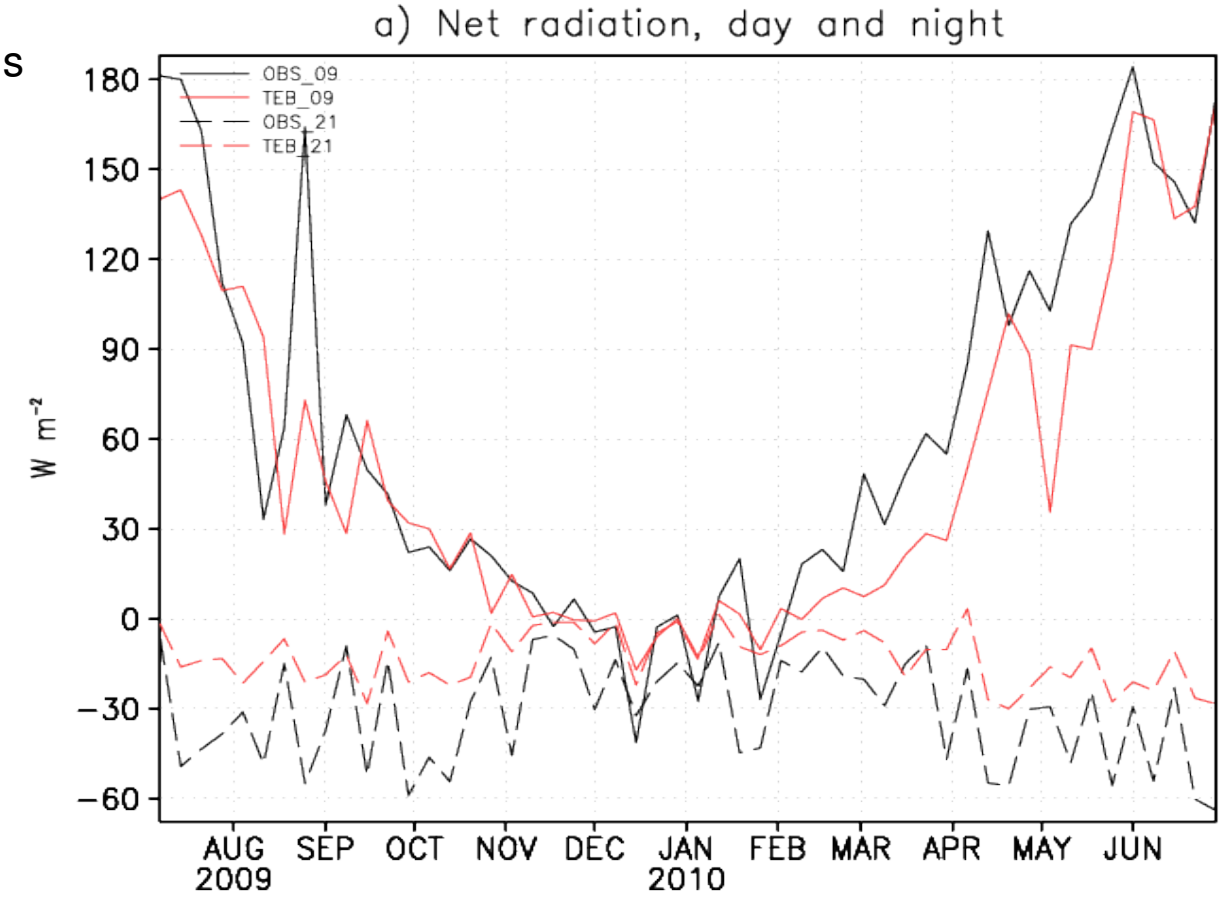
Seasonal ensemble averages: LWD and LWU

- net LW cooling throughout the year
- too strong LWD (solid): Too closed canyons?
- too weak LWU (dashed): Streets too cool, and/or too low emissivity (0.94, 0.90, 0.97 for granite, asphalt, snow)
- net result: too weak cooling by long wave radiation



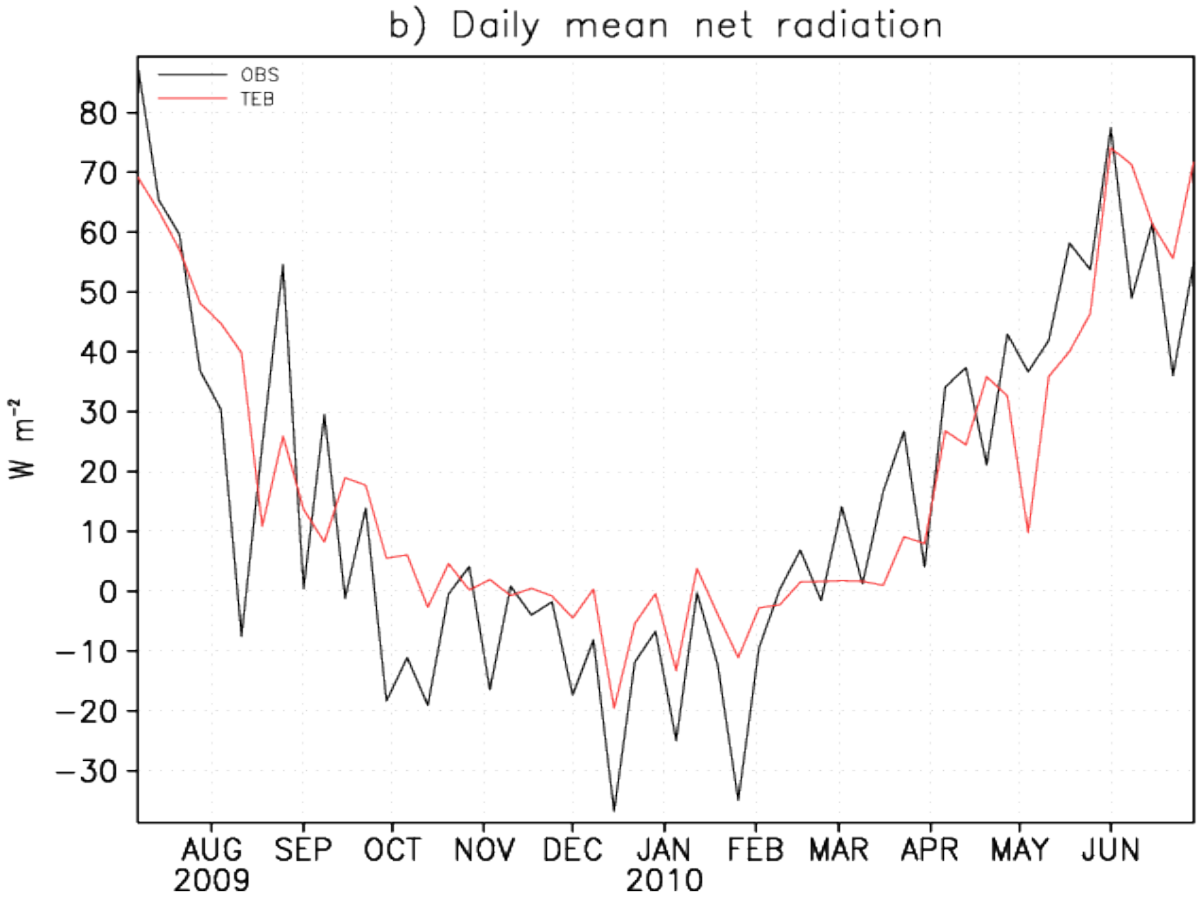
Ensemble mean Net radiation

- day time radiation (solid) is too weak in spring and summer (SW dominates)
- night time radiation (dashed) is always too positive (LW dominates)



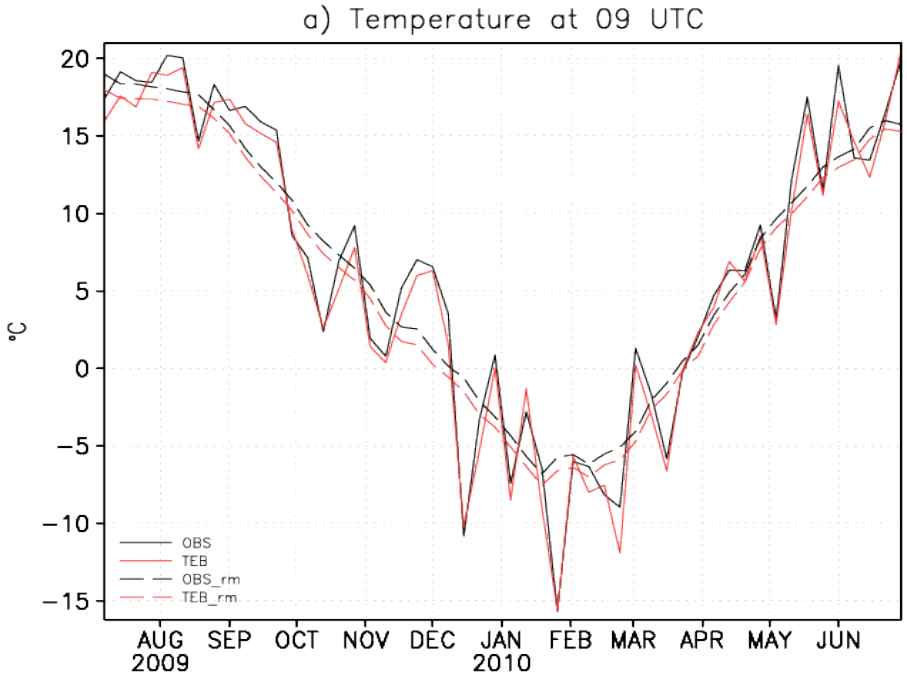
Ensemble mean Net radiation

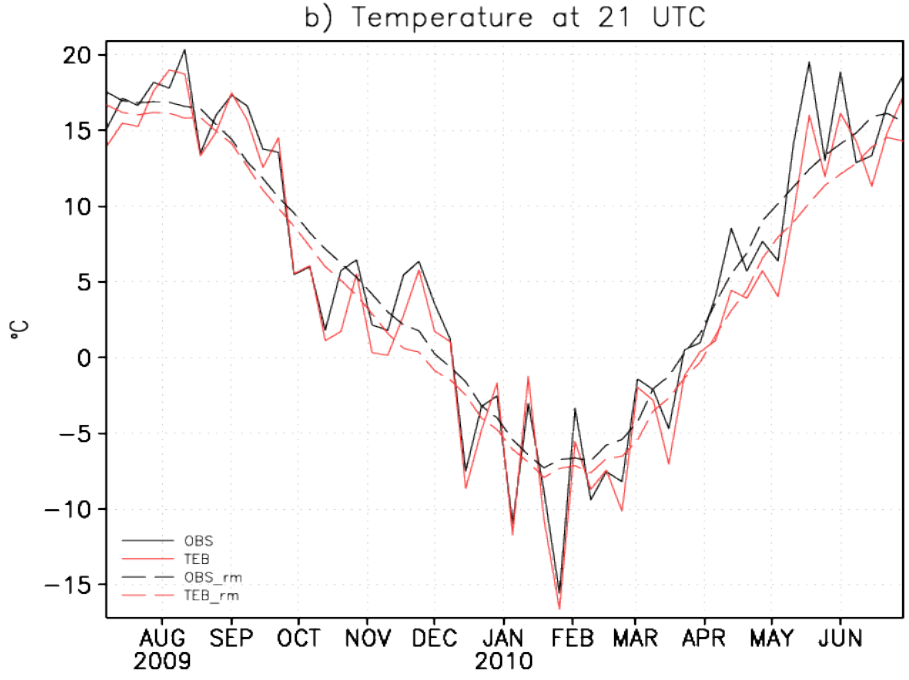
- daily mean net radiation is too high in TEB, except in spring



Ensemble mean screen level temperature

- Very high correlation at all time scales, day and night
- almost uniform cool bias, more pronounced at 21 UTC





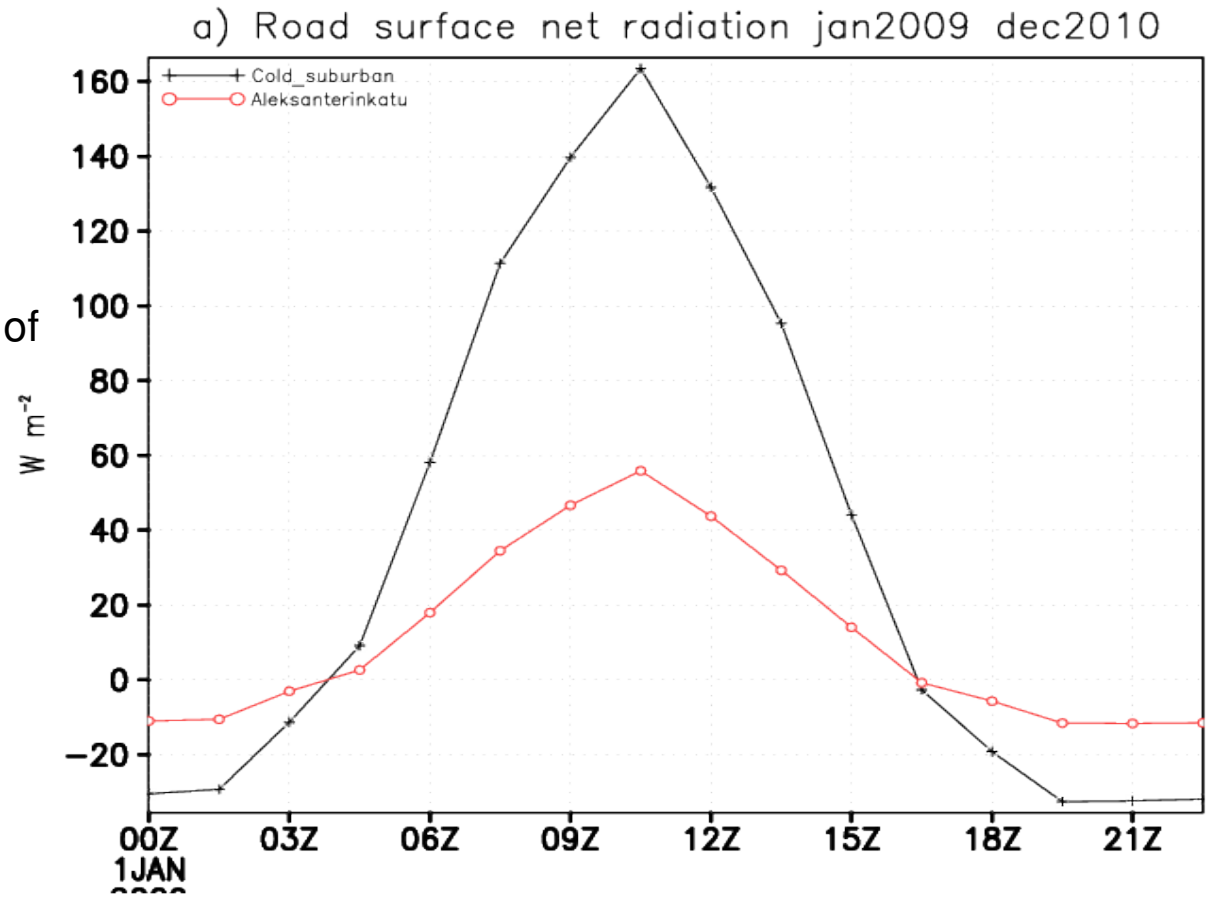
Sensitivity to urban characteristics

- ECOCLIMAP contains only one type of town in Finland: the “Cold suburban”. This is less urban than central Helsinki.

Key parameters:	Cold sb	Aleksanterink.
Building height:	10 m	26 m
Ratio wall sfc/hor sfc:	0.3	1.1
Building fraction:	0.5	0.7
Road surface albedo	0.08	0.15
Road sfc. emissivity	0.94	0.94

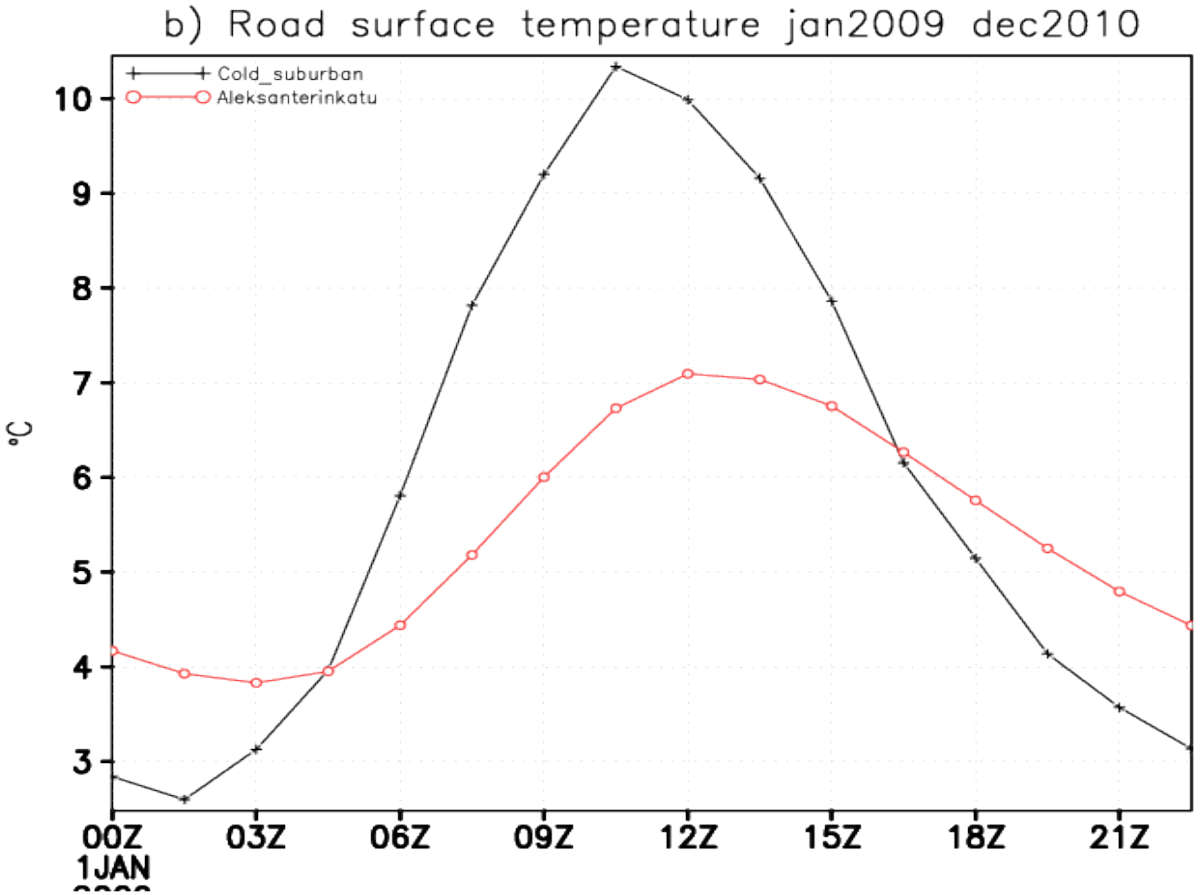
Mean diurnal cycle: Net radiation

- The effect is dramatic
- mainly caused by smaller sky view factor
- balanced, nearly, by increased turbulent fluxes of sensible and latent heat



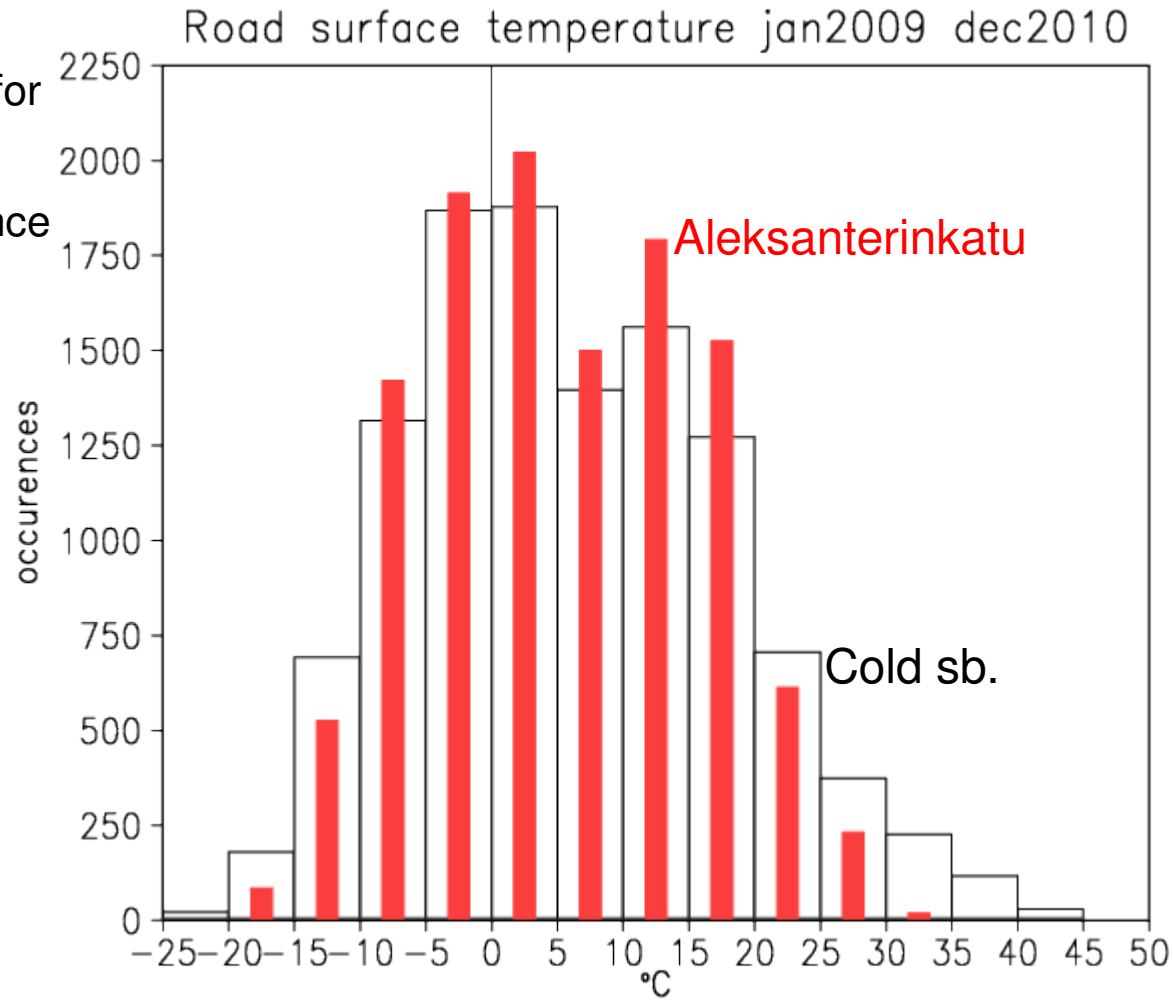
Mean diurnal cycle: Road surface temperature

- The effect is substantial



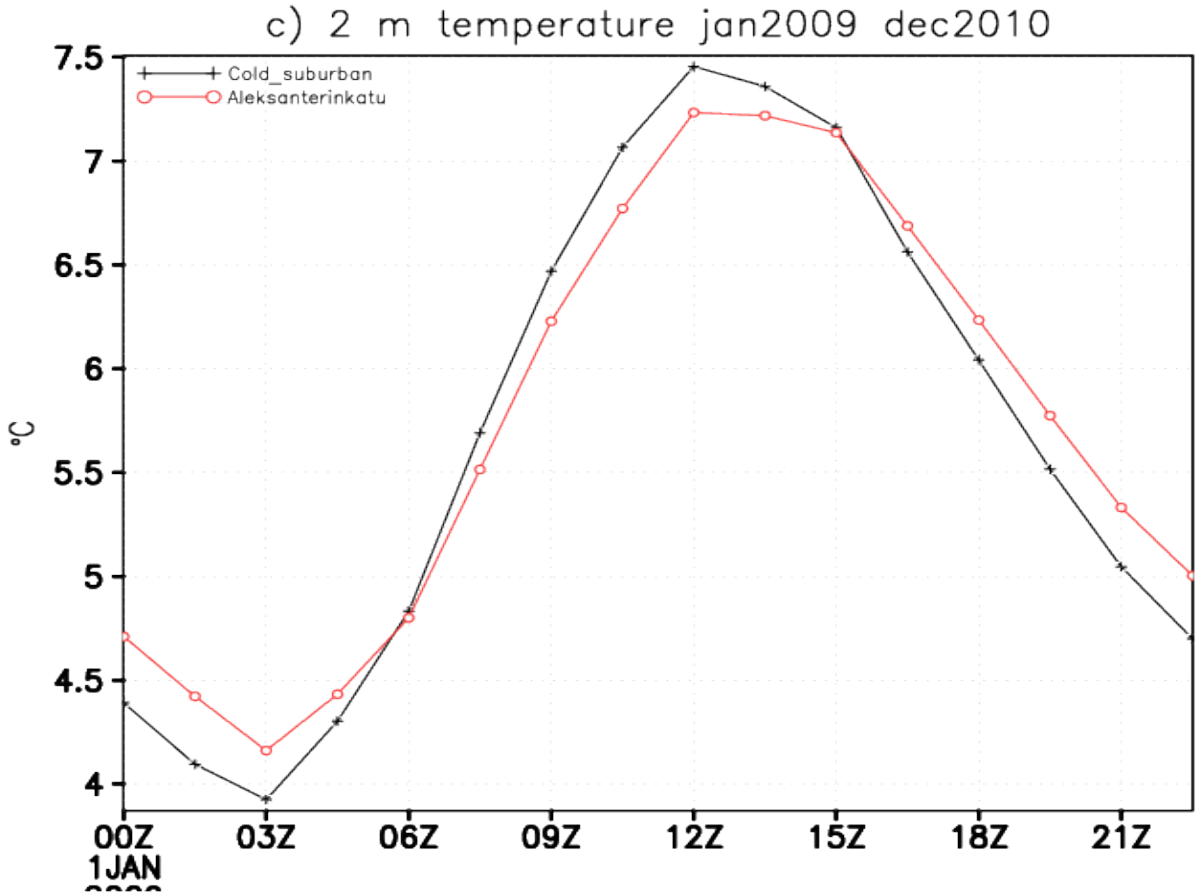
Mean diurnal cycle: Road surface temperature

- Distribution more peaked for Aleksanterinkatu
- Difference e.g. in occurrence of near-freezing temperatures



Mean diurnal cycle: screen level temperature

- The effect is tiny
- Temperature in the street canyon appears to be tied to the forcing air temperature (a weakness of off-line simulations)



Conclusions

- **Provided with good forcing data, and realistic urban characteristics, SURFEX TEB can give a good description of the radiative fluxes and temperature in street canyons of Helsinki.**
- **Radiation balance and temperature of the road surfaces in the model are sensitive to variations of the town geometry. Screen level temperature (in the model) is found to be insensitive to the same variations.**
- **In cold and snowy winters a paramterization of snow clearing would be needed.**
- **We have used an ensemble of observations taken in several streets running in different directions. This is essential for validating the short wave fluxes.**

Accnowledgement

- The research leading to these results has received funding from the European Research Council under the European Community's 7 th Framework Programme (FP7/2007-2013) / ERC grant agreement number 227915, project PBL-PMES, Sergej Zilitinkevich, koordinator.