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

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Accnowledgement

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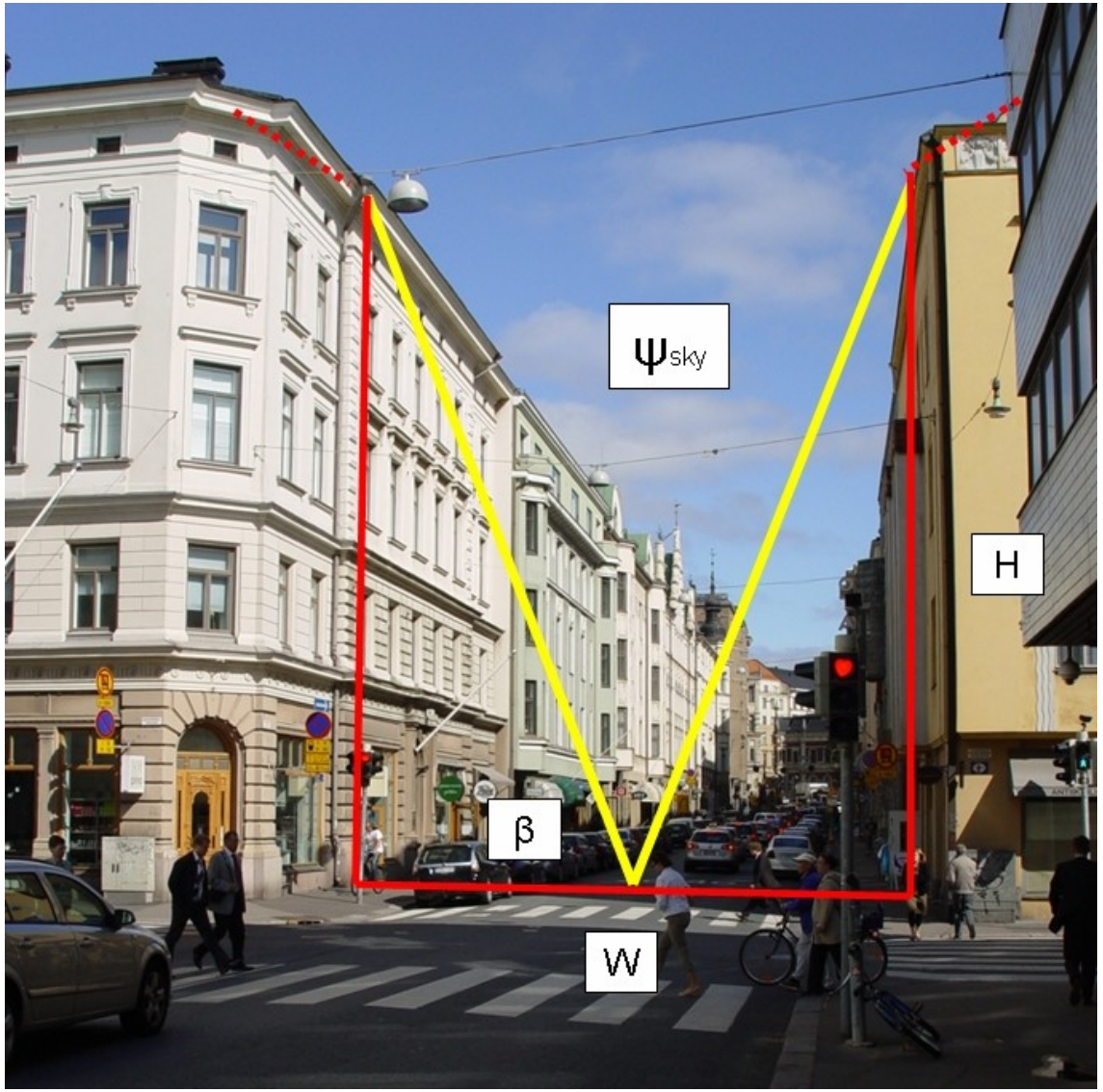
Central Helsinki in a nutshell

- **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**



Town Energy Balance model, conceptually

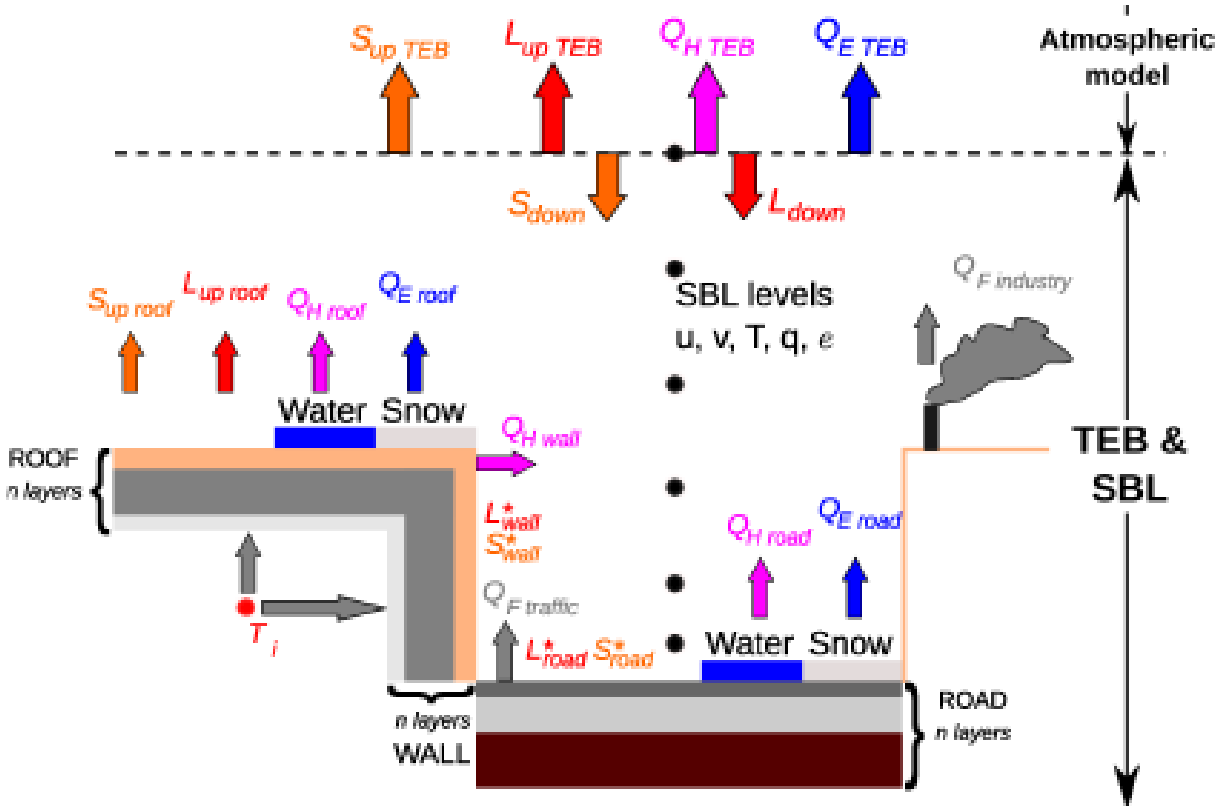


Figure 2: Schematic representation of the generic urban canyon used in TEB.

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
  - Locations in central Helsinki:
    - Bulevardi, Fredrikinkatu, Iso Robertinkatu, Kluuvikatu, Museokatu, Mariankatu,Tehtaankatu
  - 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

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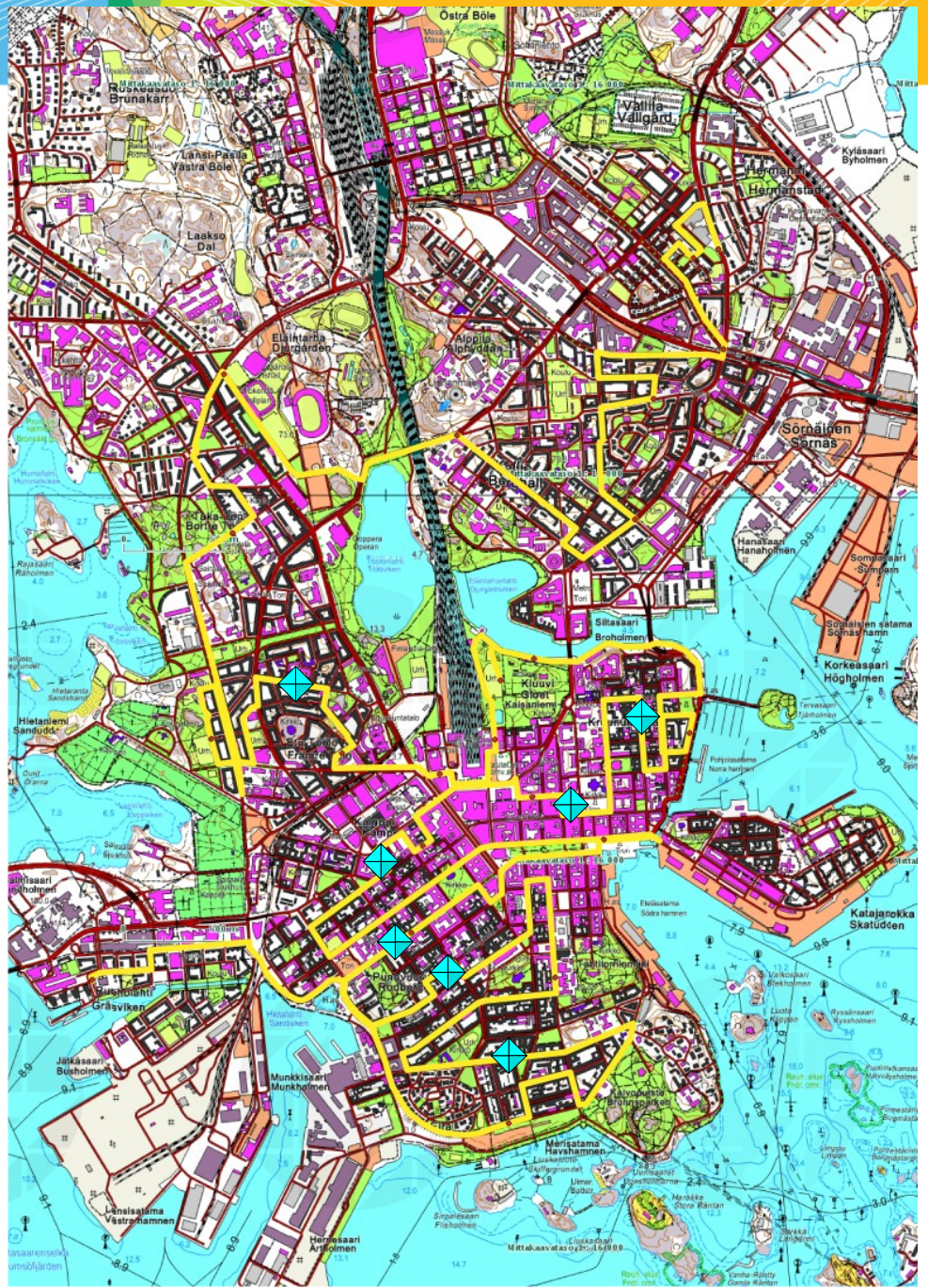
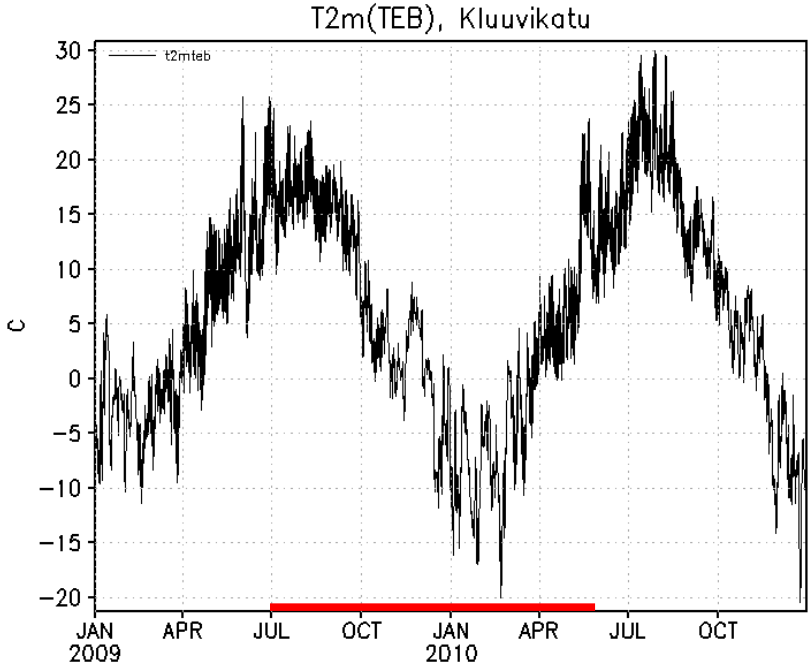
Mobile soundings:

- along yellow line
- used locations: ✥
- T, (T_{wet}), SWD, SWU, LWD, LWU
- Day (~09 UTC) and night (~21 UTC) every Tuesday
- local midday and midnight at about 10:20 and 20:20 UTC

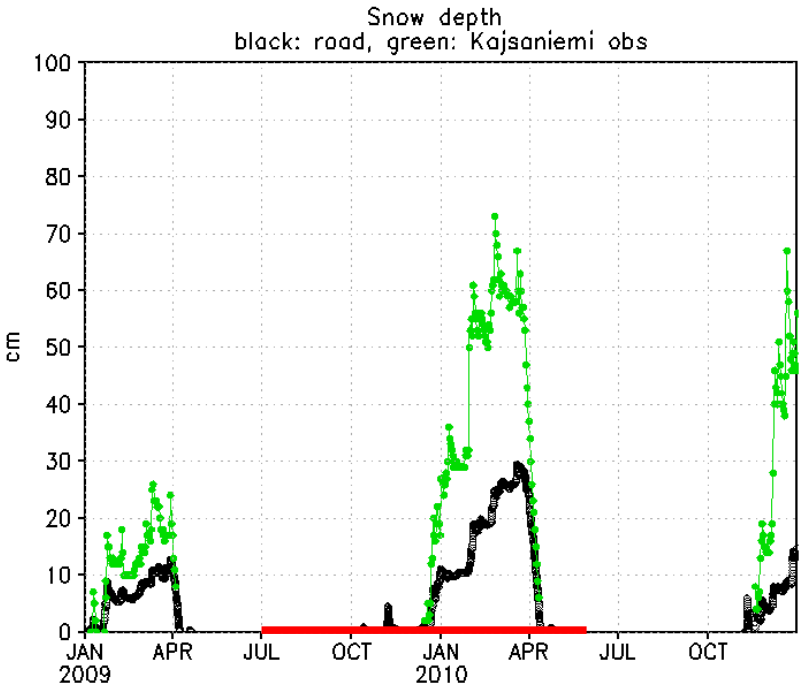


Example of model output:

- **Run initiated on January 1 2009, dt = 90 min**



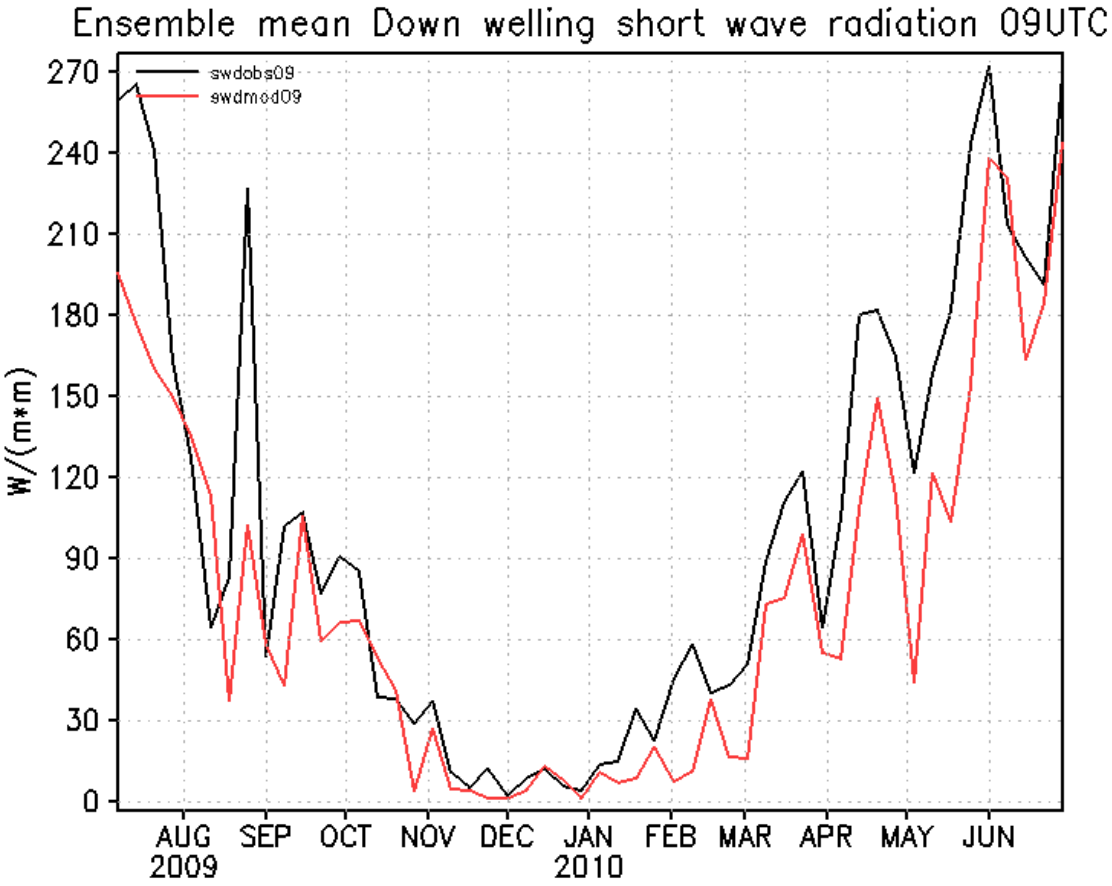
Temperature



Snow depth

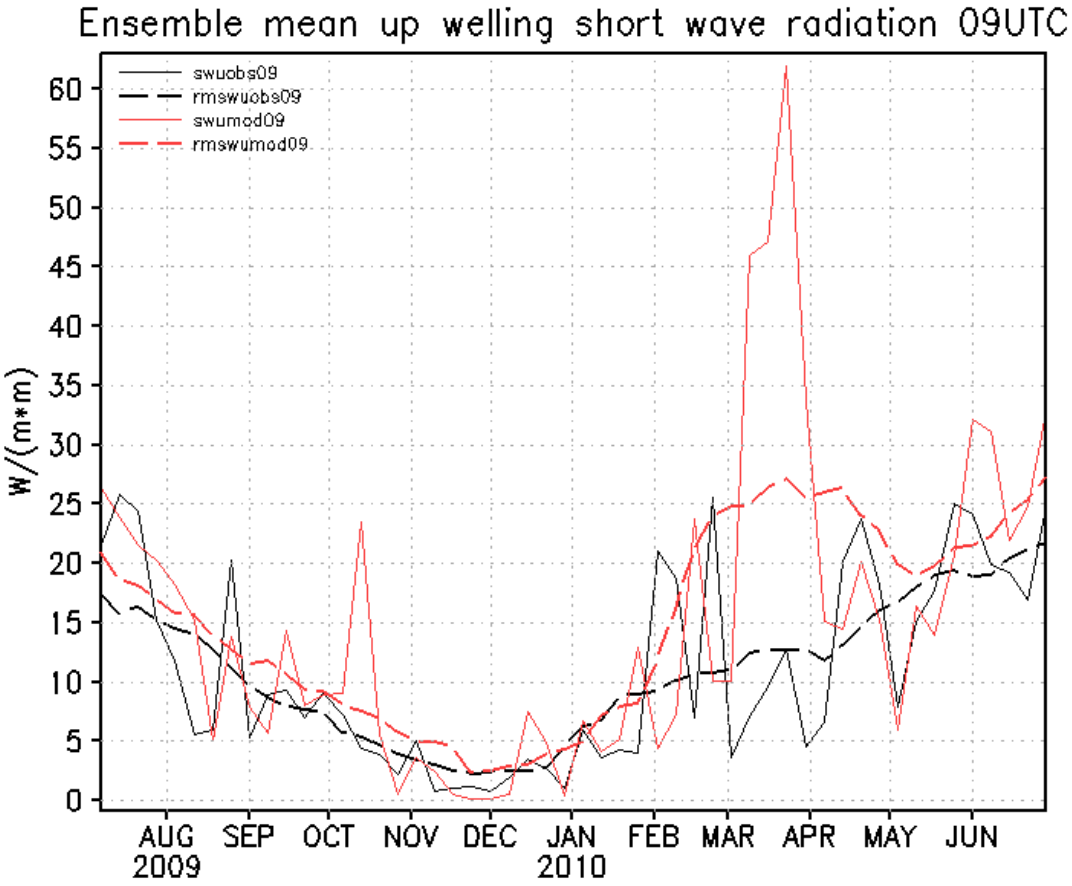
Ensemble averages: SWD

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



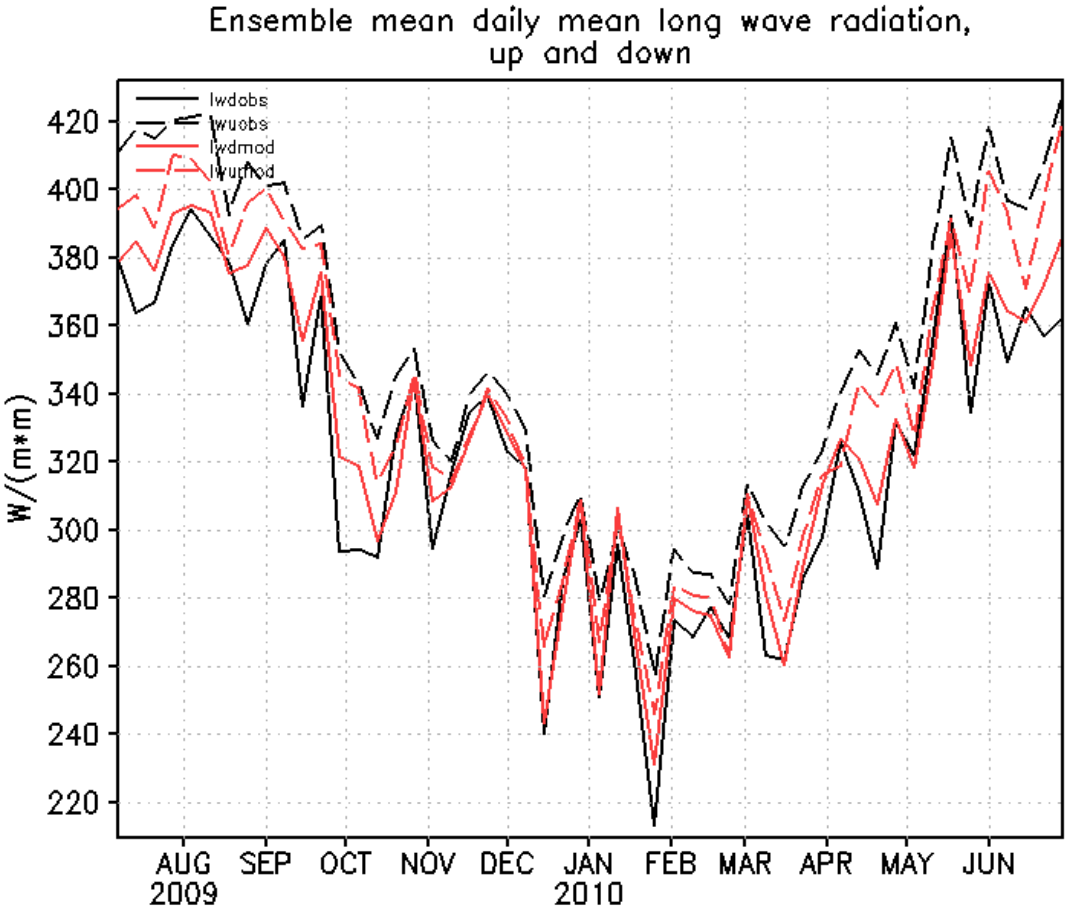
Ensemble averages: SWU

- controlled by SWD and reflection from the street surfaces (bare road and snow)
- high 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



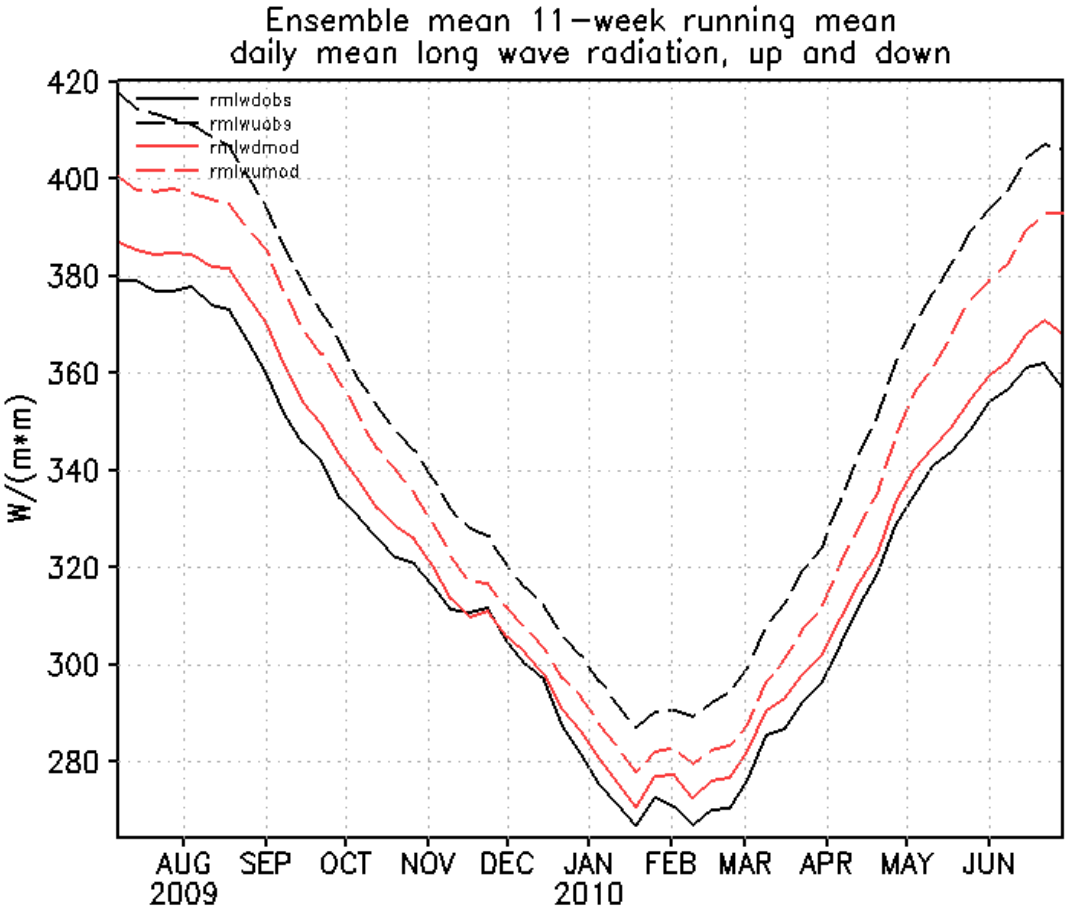
Ensemble averages: LWD and LWU

- 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
- net cooling effect in all seasons
- model fluxes correlate well with the measurements at all time scales
- but there are some mainly systematic differences...



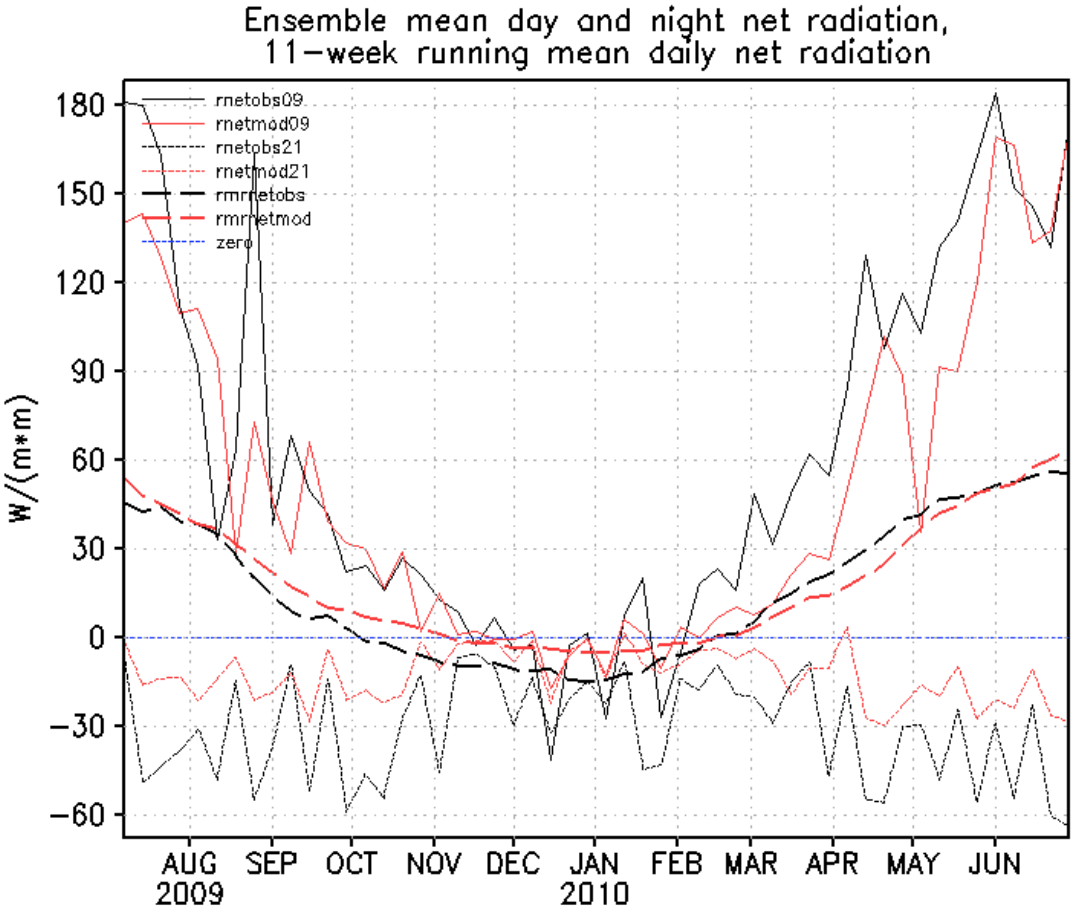
Seasonal ensemble averages: LWD and LWU

- 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



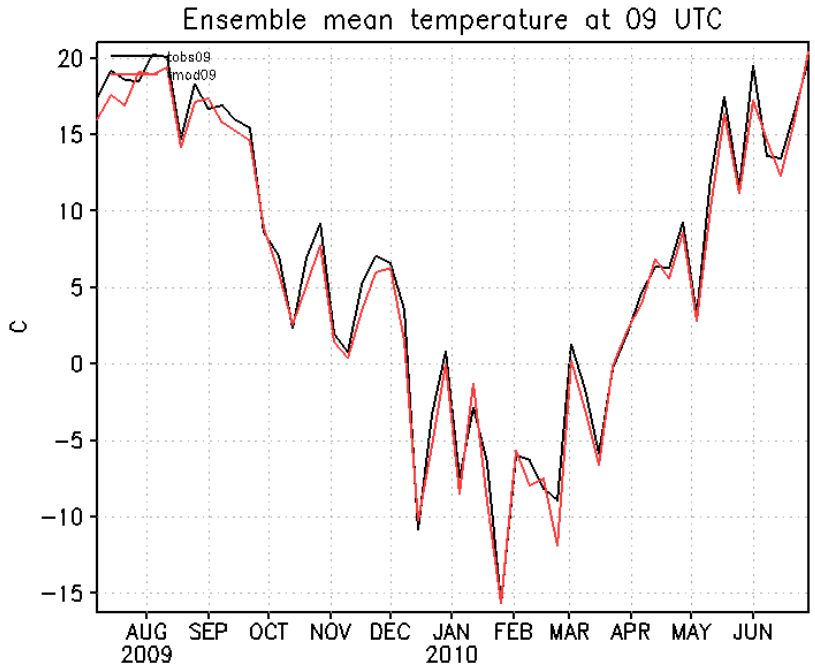
Ensemble mean Net radiation

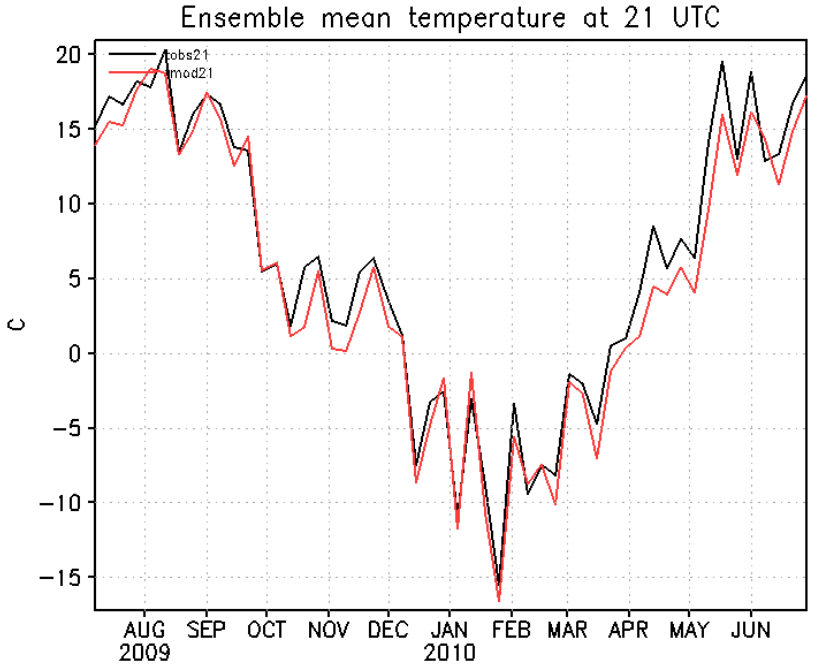
- day time radiation (thin solid) is weak in spring and summer (SW dominates)
- night time radiation (thin dashed) is always high (LW dominates)
- seasonal average daily mean (thick dashed) is high, except in spring



Ensemble mean screen level temperature

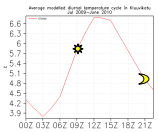
- Very high correlation at all time scales, day and night

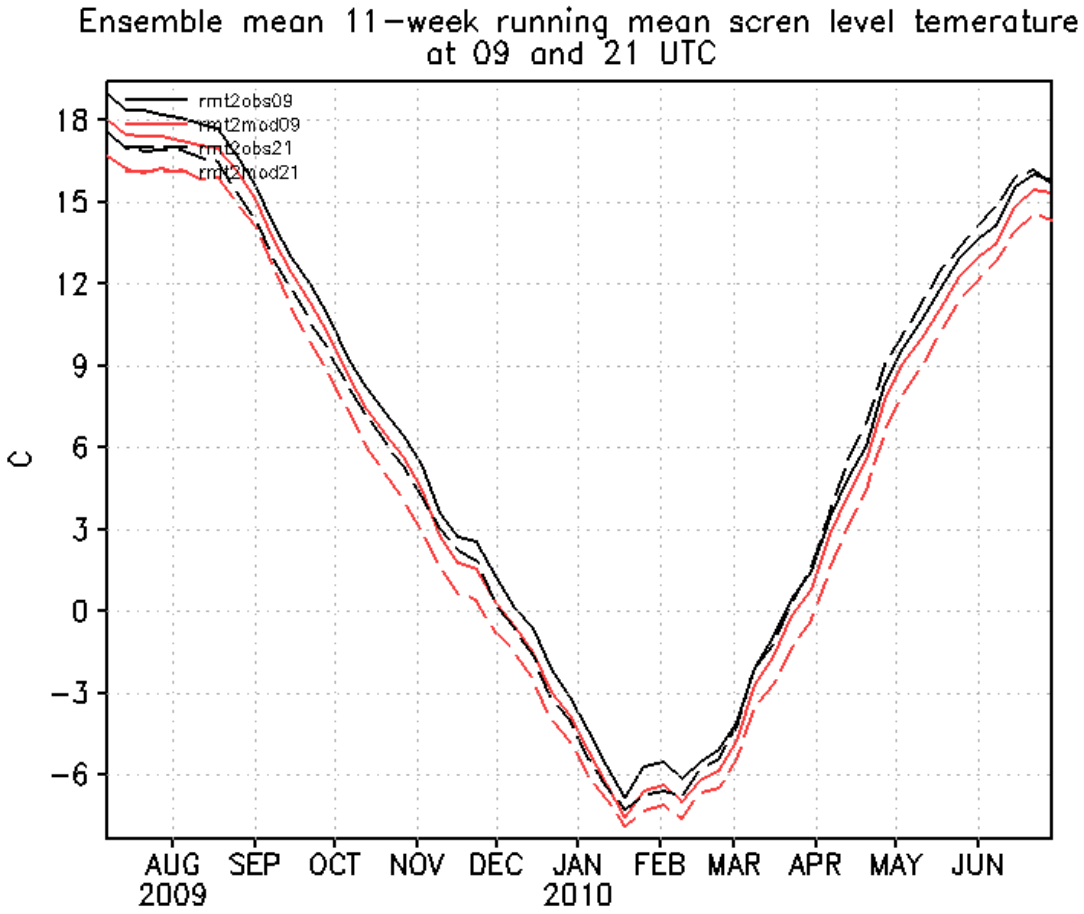


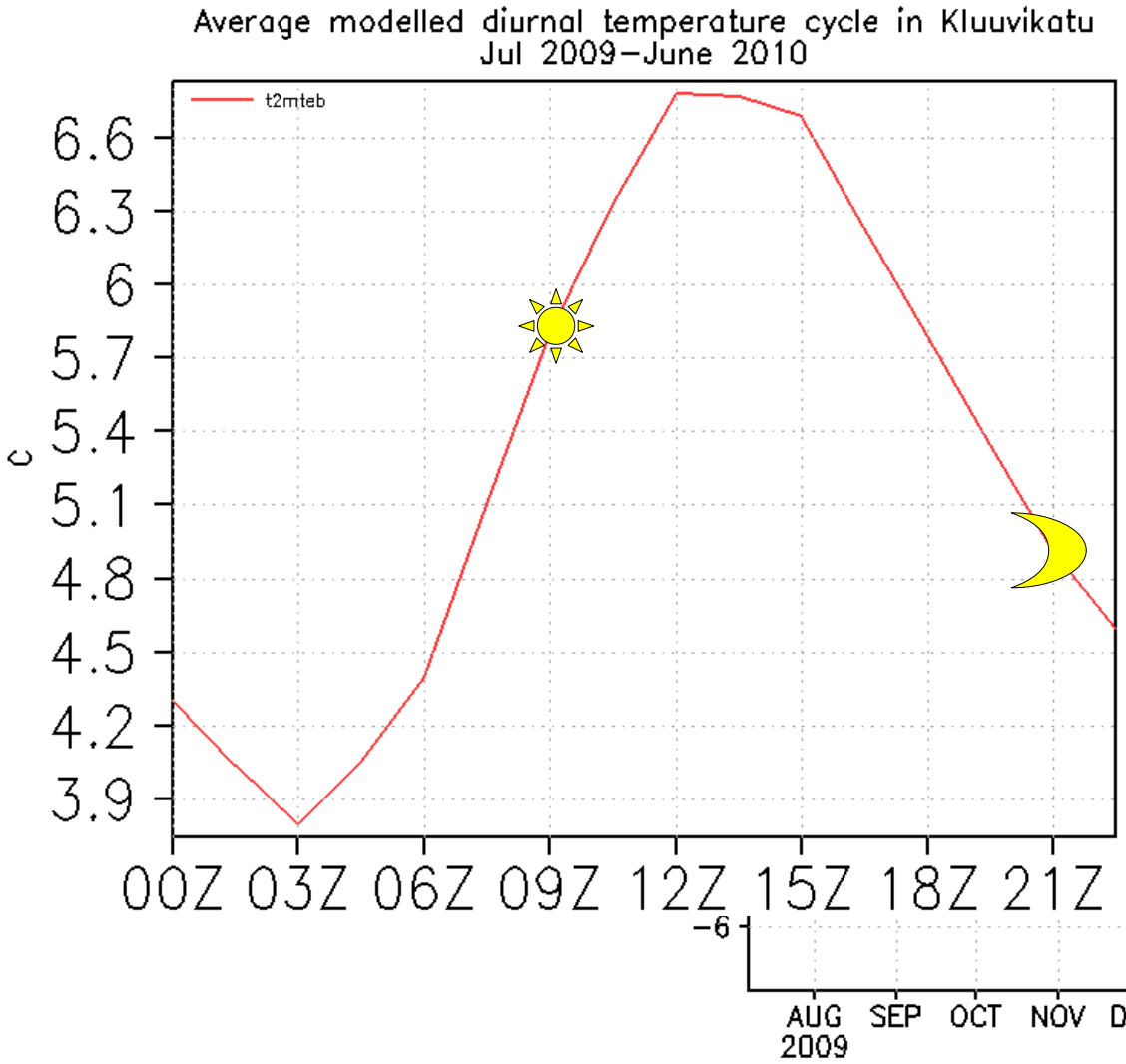


Ensemble mean seasonal T2m, 09 & 21 UTC

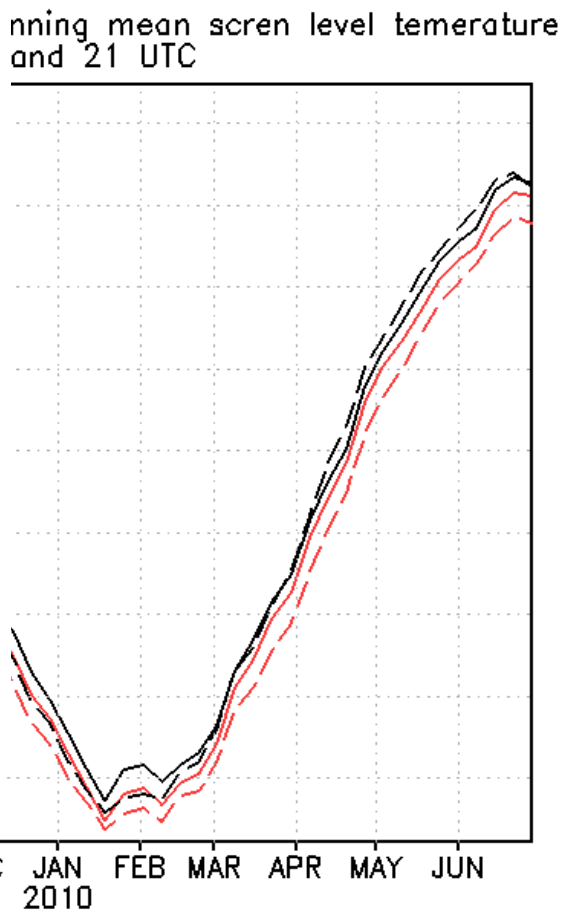
- A very even cool bias
- better at 09 than at 21 UTC
- observed temperature higher at 21 UTC than at 09 in spring, not seen in the model
- Note:






Average modelled diurnal temperature cycle in Kluuvikatu
Jul 2009–June 2010
t2mteb
c
6.6
6.3
6
5.7
5.4
5.1
4.8
4.5
4.2
3.9
00Z 03Z 06Z 09Z 12Z 15Z 18Z 21Z

09 & 21 UTC


nning mean scren level temerature
and 21 UTC
-6
AUG
2009
SEP
OCT
NOV
DEC
JAN
2010
FEB
MAR
APR
MAY
JUN

Importance of urban characteristics

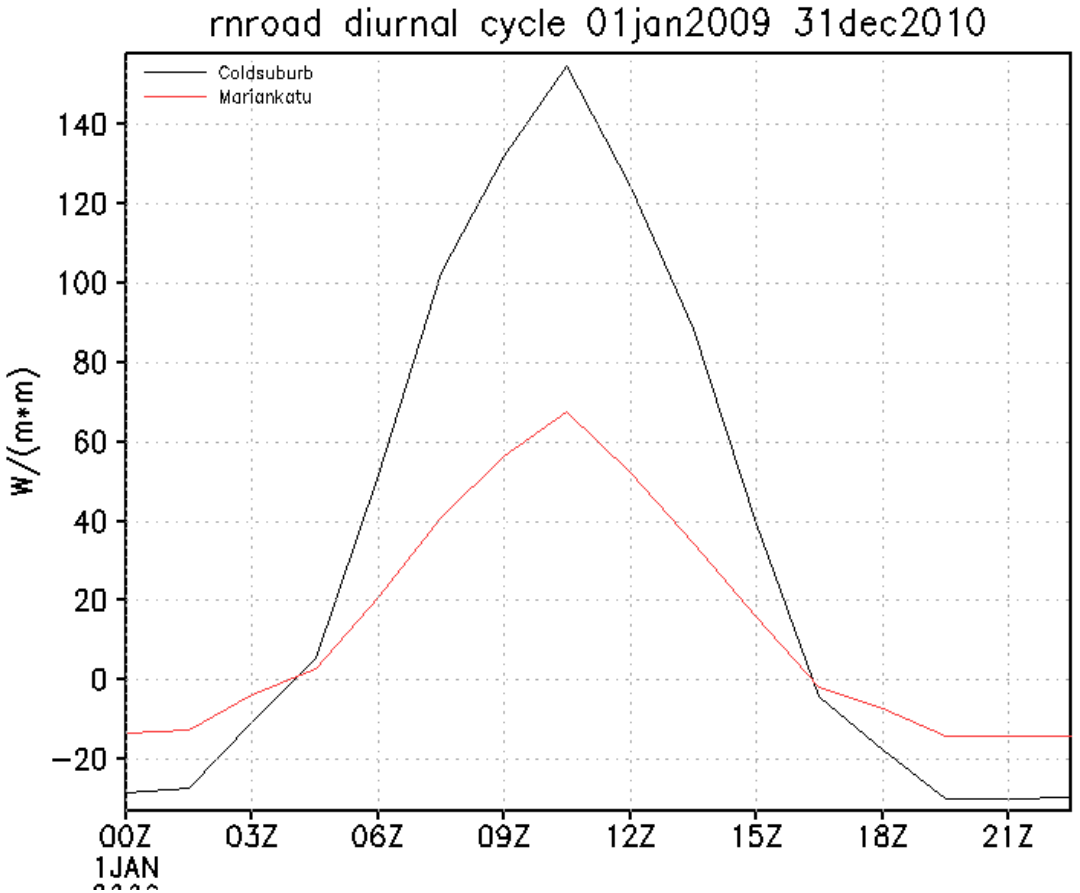
- **ECOCLIMAP contains only one type of town in Finland: the "Cold suburban". This is less urban than central Helsinki.**

Key parameters

	Cold sb	Helsinki
Building height:	10 m	20 - 30 m
Wall sfc over hor sfsc:	0.3	0.8 - 1.3
Building fraction:	0.5	0.7

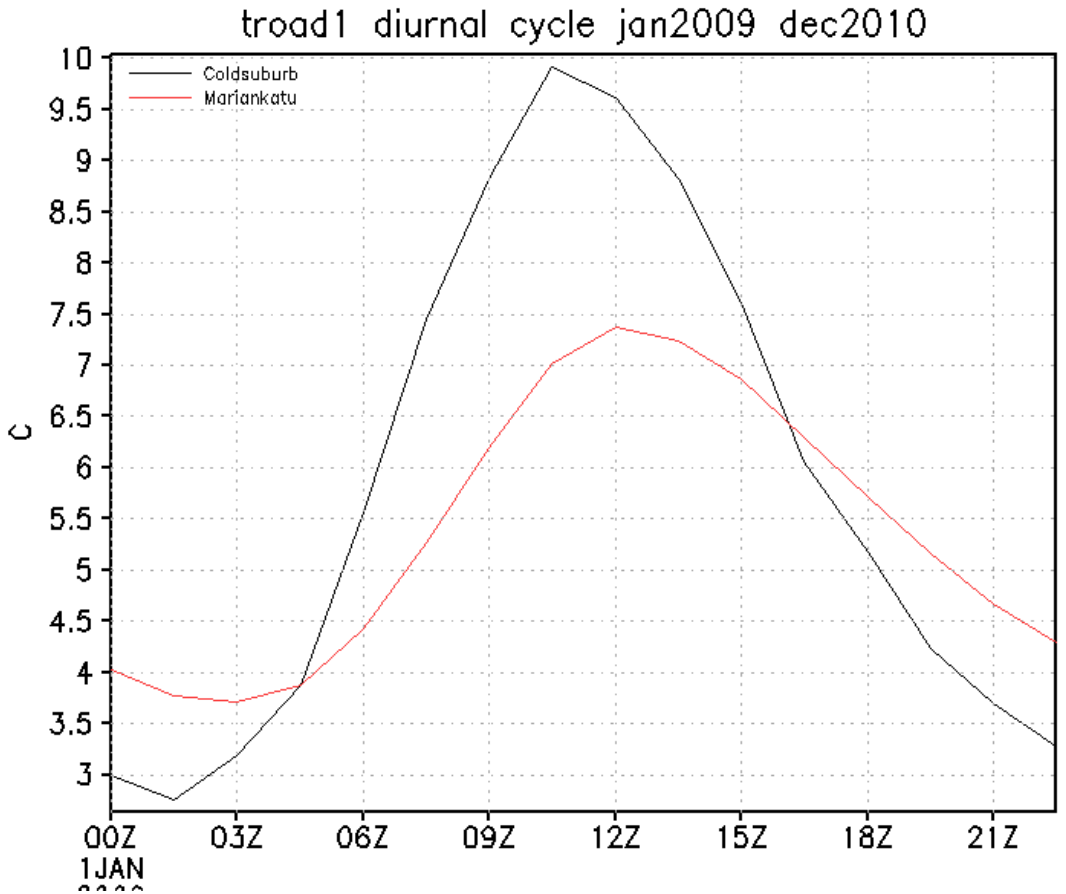
Mean diurnal cycle: Net radiation

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



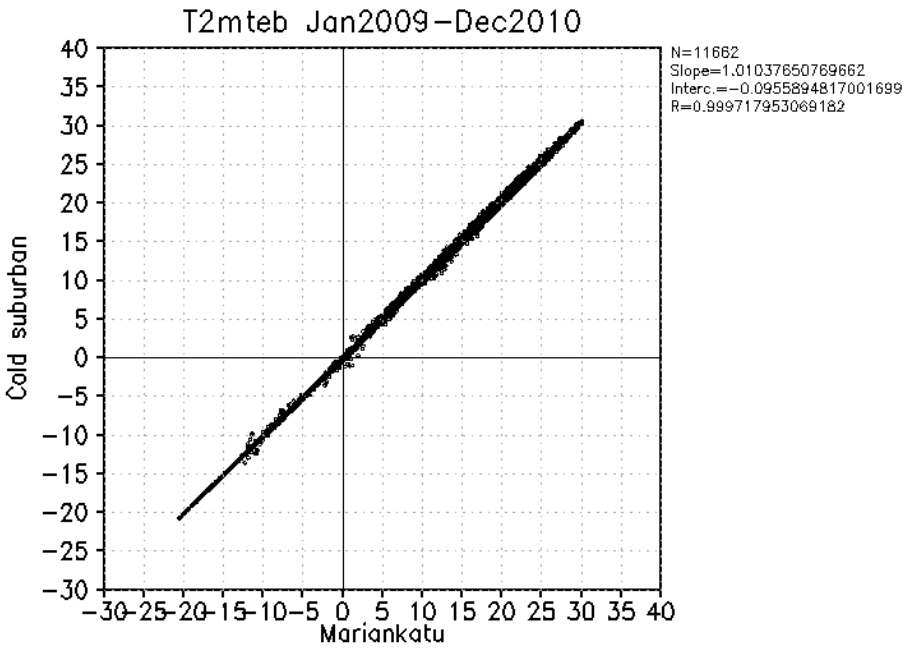
Mean diurnal cycle: Road surface temperature

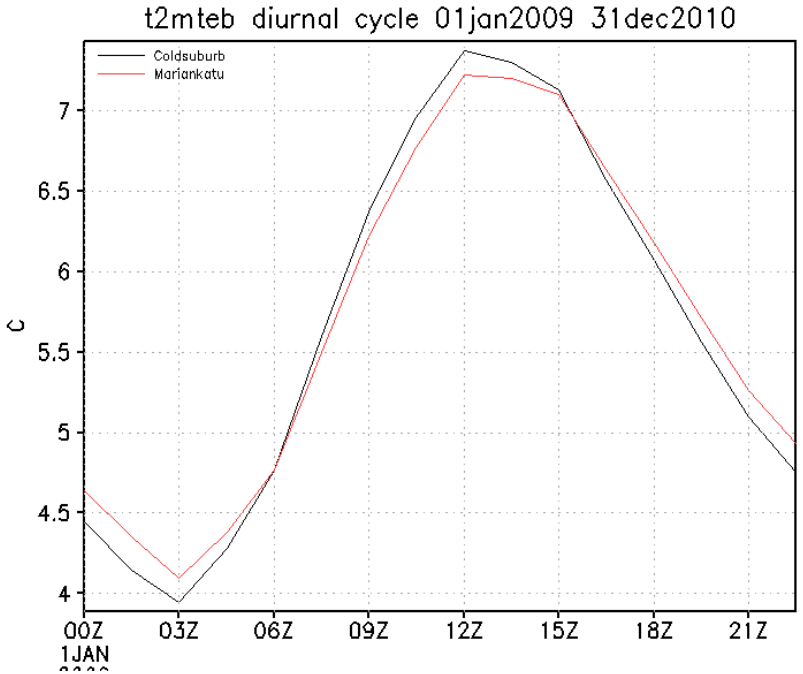
- The effect is substantial
- Important for predicting icy roads and pavements, et c.



Mean diurnal cycle: screen level temperature

- The effect is tiny





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.**