# The influence of COSMO model developments and parameters affecting the boundary layer on urban climate modelling with TERRA_URB

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## Motivation

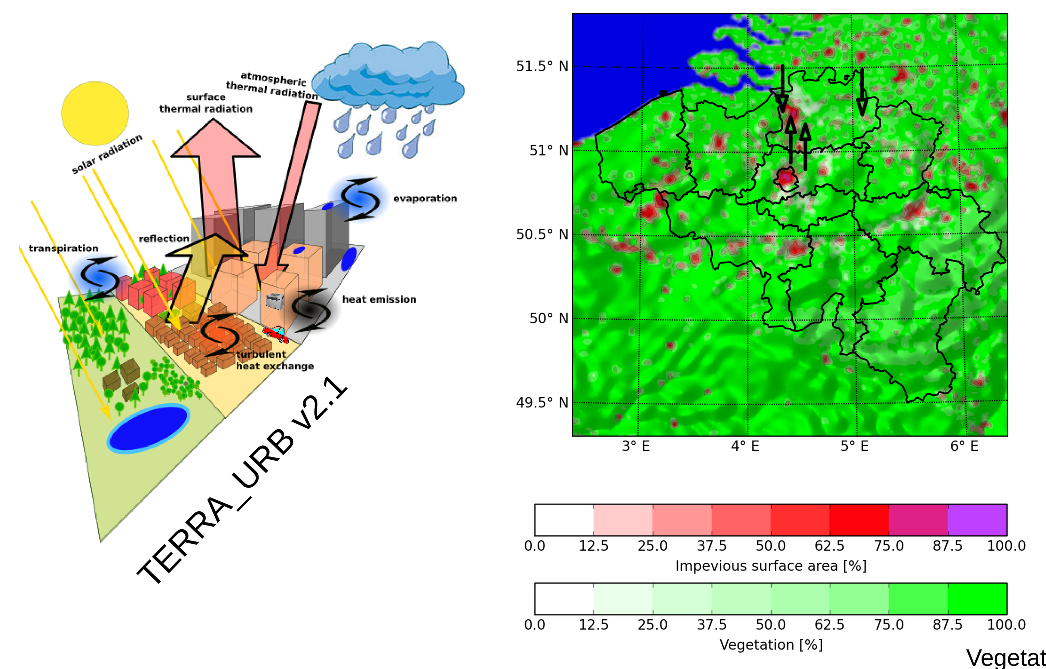
• A substantial underestimation of nocturnal urban heat islands with an out-of-the-box setup of COSMO-CLM coupled to TERRA_URB is experienced for cities in Belgium[1].
• This is despite TERRA_URB's satisfactory results of reproducing the urban surface energy balance during intensive urban observation campaigns for Toulouse, Basel and Singapore[2,3].
• Idealized boundary-layer model demonstrates that urban heat island intensities depend on the stable stratification of the vertical temperature profiles[4].
• The question rises what's the role of an apparent underestimation of the stable stratification and overestimated nocturnal rural temperatures on the underestimation of the urban heat island intensity.

## Objectives

• Investigate sensitivity of urban heat islands to model parameters affecting the boundary layer through:
  - changes in the model parameters of boundary-layer turbulent vertical transport
  - inclusion of a vegetation insulation parameterization[5]
• Provide recommendations for improved urban-climate modelling with COSMO

## Experiments

• Belgian domain, 2.8km horizontal spacing
• Nested in ECMWF forecasts, 12.5 km grid spacing
• Using COSMO5.0_clm8 + TERRA_URB v2.1
• Mid-summer: 2012/07/21 → 2012/08/20 with 3 weeks of spin-up

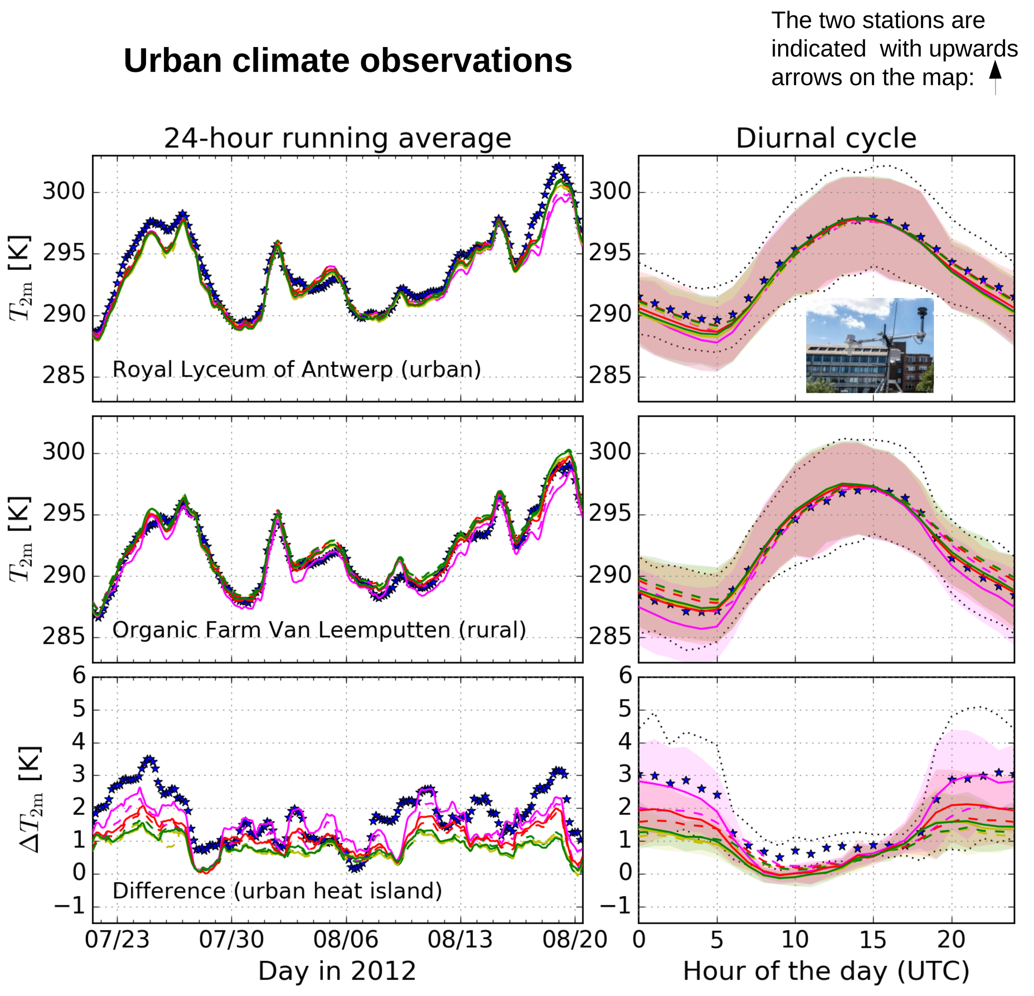



Length scale of subscale surface patterns over land [m], which scales the tke circulation term

Minimal diffusion coefficients of vertical turbulent transport

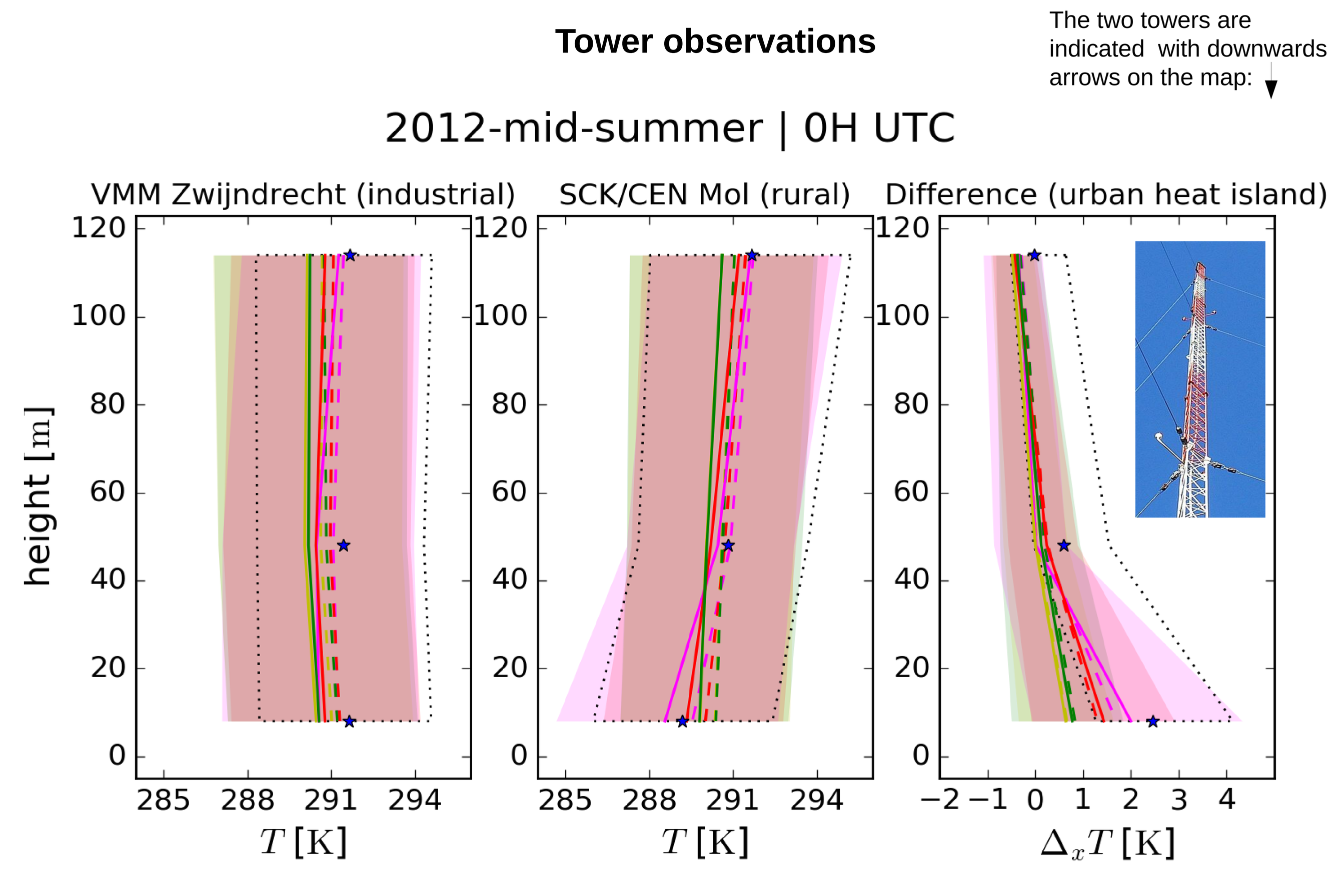
Vegetation skin effect is turned on for the natural tiles using a skin-layer conductivity of $10 Wm^{-2}K^{-1}$, which agrees with observations over grassland[5]. It is switched off for the urban tiles where no vegetation is present.

| Experiment ID | tkmmin and tkhmin [$m^2s^{-1}$] | pat_len [m] | Vegetation skin effect |
|---|---|---|---|
| TKDEF_PLDEF | 0.4 (default) | 500 (default) | no |
| TKDEF_PL010 | 0.4 | 10 | no |
| TK002_PL500 | 0.02 | 500 | no |
| TK002_PL010 | 0.02 | 10 | no |
| TKDEF_PLDEF_SK | 0.4 | 500 | yes |
| TKDEF_PL010_SK | 0.4 | 10 | yes |
| TK002_PLDEF_SK | 0.02 | 500 | yes |
| TK002_PL010_SK | 0.02 | 10 | yes |
| OBS | | | |




## Results and discussion

• Both the vegetation insulation effect and turbulence parametrization influence nocturnal temperatures and stability of the nocturnal boundary layer temperature profiles.
• The effect is mainly established in the rural areas and it is much smaller in the urban areas.
• As such, they influence the (NBL and CL) urban heat islands – confirming previous idealized studies – by up to a factor 3.
• Non-linear responses: the different parameters sensitivities intensify each other.
• Results are consistent with sensitivity experiments over Moscow[6].




## Conclusions and outlook

– Results suggest that optimisation of boundary-layer representation in COSMO has large potential in improved urban-climate modelling, especially the alleviation of underestimated nocturnal heat islands.
– In order to avoid overtuning, a physical basis of optimized parameters needs to be investigated.
– Remaining underestimation of urban heat islands needs to be tackled by considering:
 (1) improved consistency between observed and modelled temperatures
 (2) additional detail in surface and urban morphological information
 (3) improved model physics (urban, rural, upper air…) of the coupled model system
– Tests with additional COSMO developments need to be done regarding the new TKE turbulence scheme[7,8] and explicit vegetation shading.

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