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Impact of model resolution and urban parameterization on urban climate simulation: a case study for Zürich

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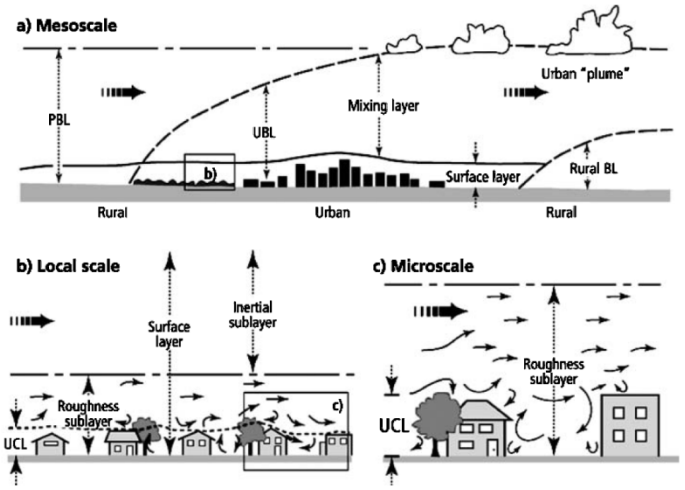
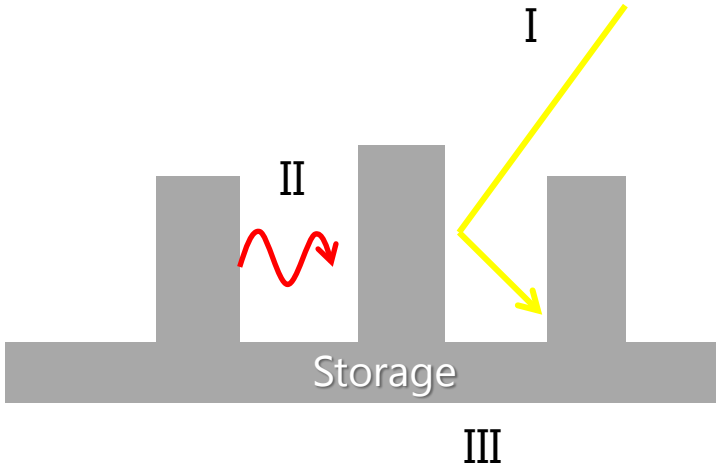
Modelling the urban atmosphere

- Multiscale problem
  - Urban Boundary Layer
  - Roughness Sub-Layer
  - Urban Canopy Layer



From Grimmond et al., 2006

- Modifications of the energy budget
  - I: radiation trapping (short wave)
  - II: radiation trapping (long wave)
  - III: greater heat storage
  - IV: limited latent heat fluxes
  - Others



State of the Art

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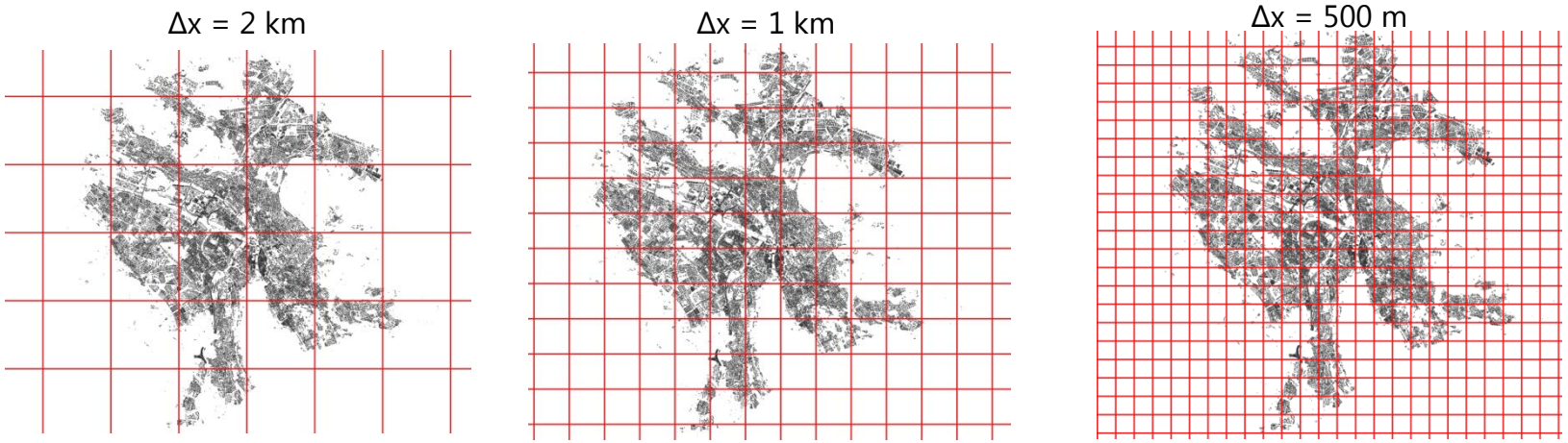
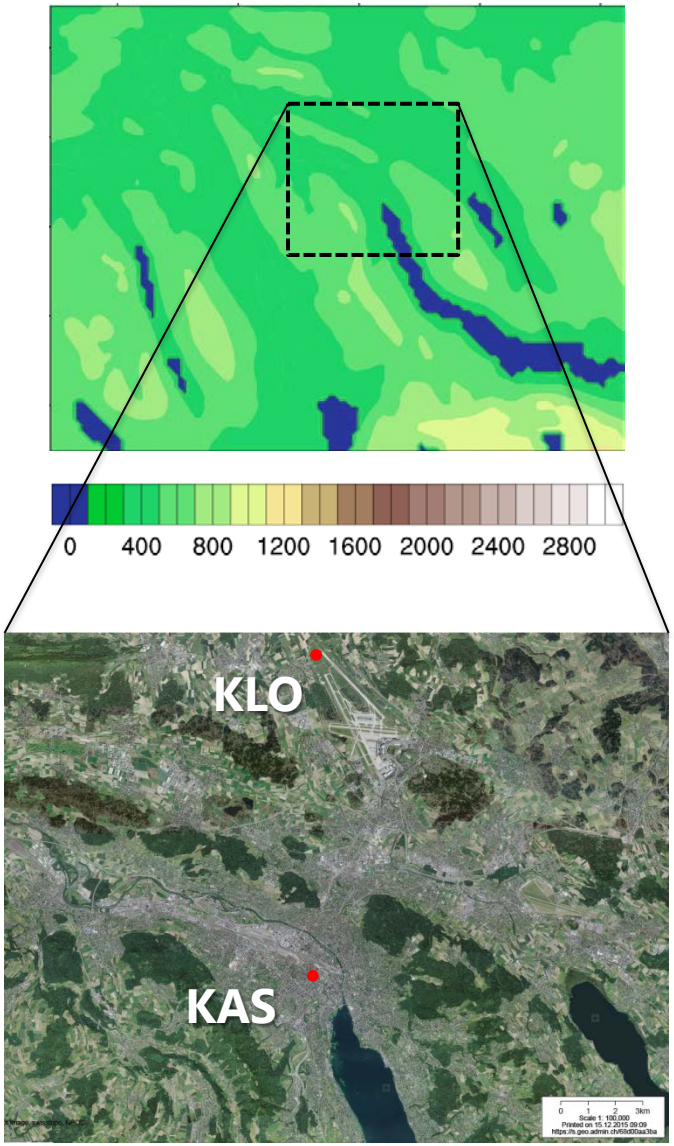
- Actual studies
  - Large cities -> model resolution 2-1 km
  - Urban parameterization of differnet complexity



- Questions
  - Impact of model resolution
  - Impact of urban canopy model complexity

Experiment set-up

- COSMO CLM v5.0
  - Δx = 2km , 1 km , 500 m
  - Domain: 100x100, 75x75, 50x50 km
  - Vert. Lev = 76
  - IC/BC: COSMO-2 Analysis MeteoSwiss
  - Turbulence: prognostic scheme (1D)
- Urban parameterization
  - TERRA-URB (bulk)
  - DCEP (multi-layer)
- Surface observations
  - KAS – Urban Downtown
  - KLO – Semi-rural, Airport
- Event: Heat Wave 2015 (18days)



Urban Measurement Site

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Urban canopy model: TERRA-URB

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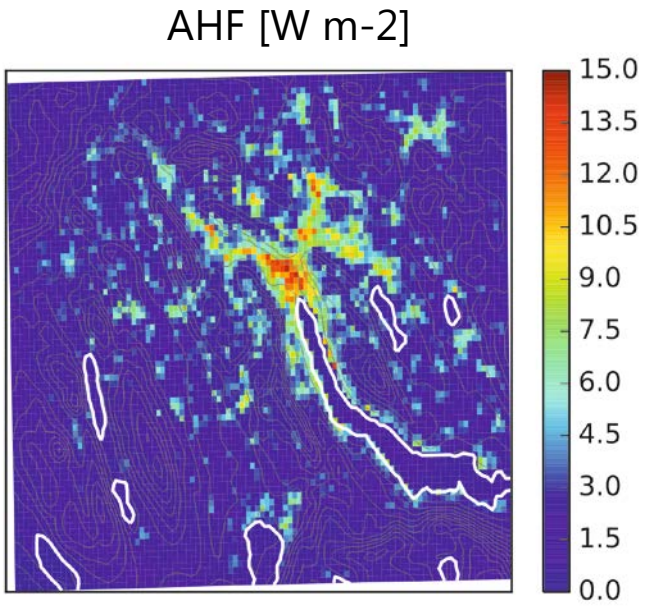
- Urban extension of TERRA-ML
  - Bulk values for thermal and radiative properties (α, ε, C_P)
  - Thermal roughness length parameterization
  - Impervious water-storage parameterization
  - Tile approach

- Input data required
  - Impervious Surface Area (ISA)

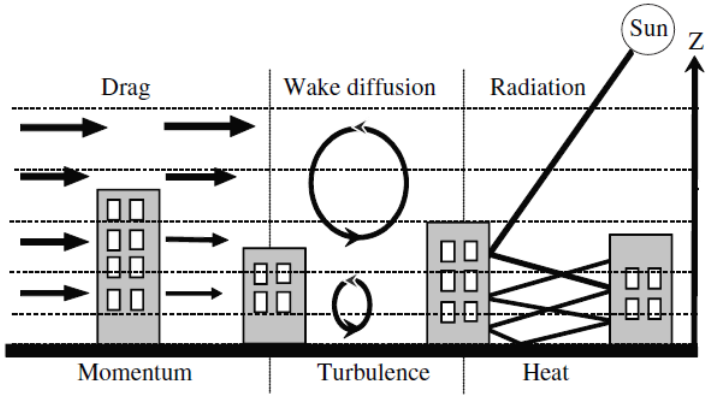
    res ~ 300 m
  - Antrophogenic Heat Flux (AHF)

    orig ~ 7 km reaggr. with ISA

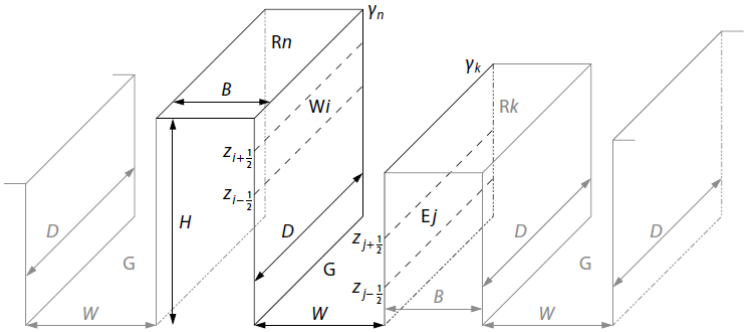


Urban canopy model: DCEP

- Based on Building Effect Parameterization (BEP) by Martilli
  - Multi-layer model
  - Momentum, turbulence and heat
  - Extended by Schubert (2012)
- Input data required
  - 3D building model
  - Urban fraction (from ISA)
- This study
  - 4 canyon dir , 12 vertical lev
  - Urban vegetation: LAI = 3, PLCOV = 0.8, Z0 = 0.1 m

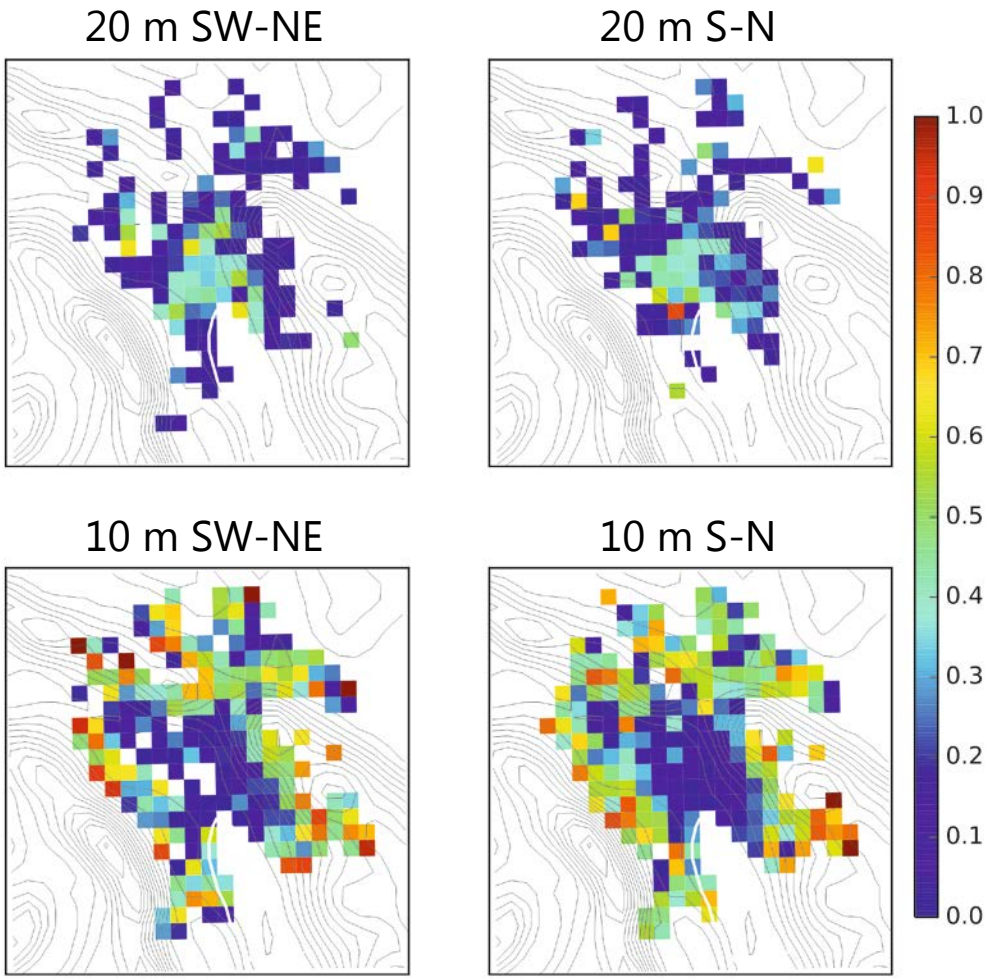


Adapted from Chen et al., 2011



From Schubert, 2013

Urban input data (DCEP) for Zürich (example)



BUILDING DISTRIBUTION (roof tops)
500 m resolution

Spatial variability of T2

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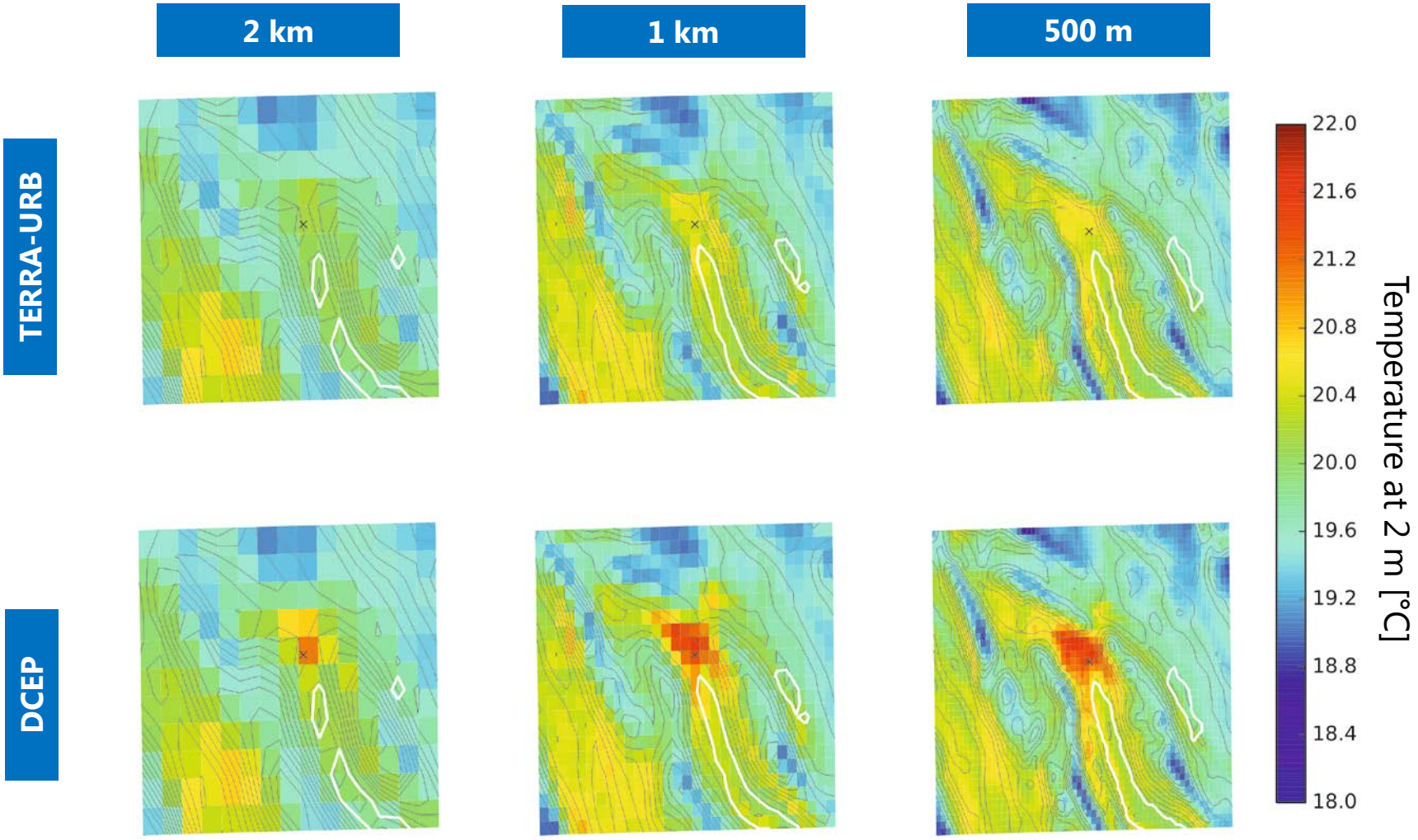

Time = 00 UTC, period averaged

Spatial variability of T2 (interpolated)

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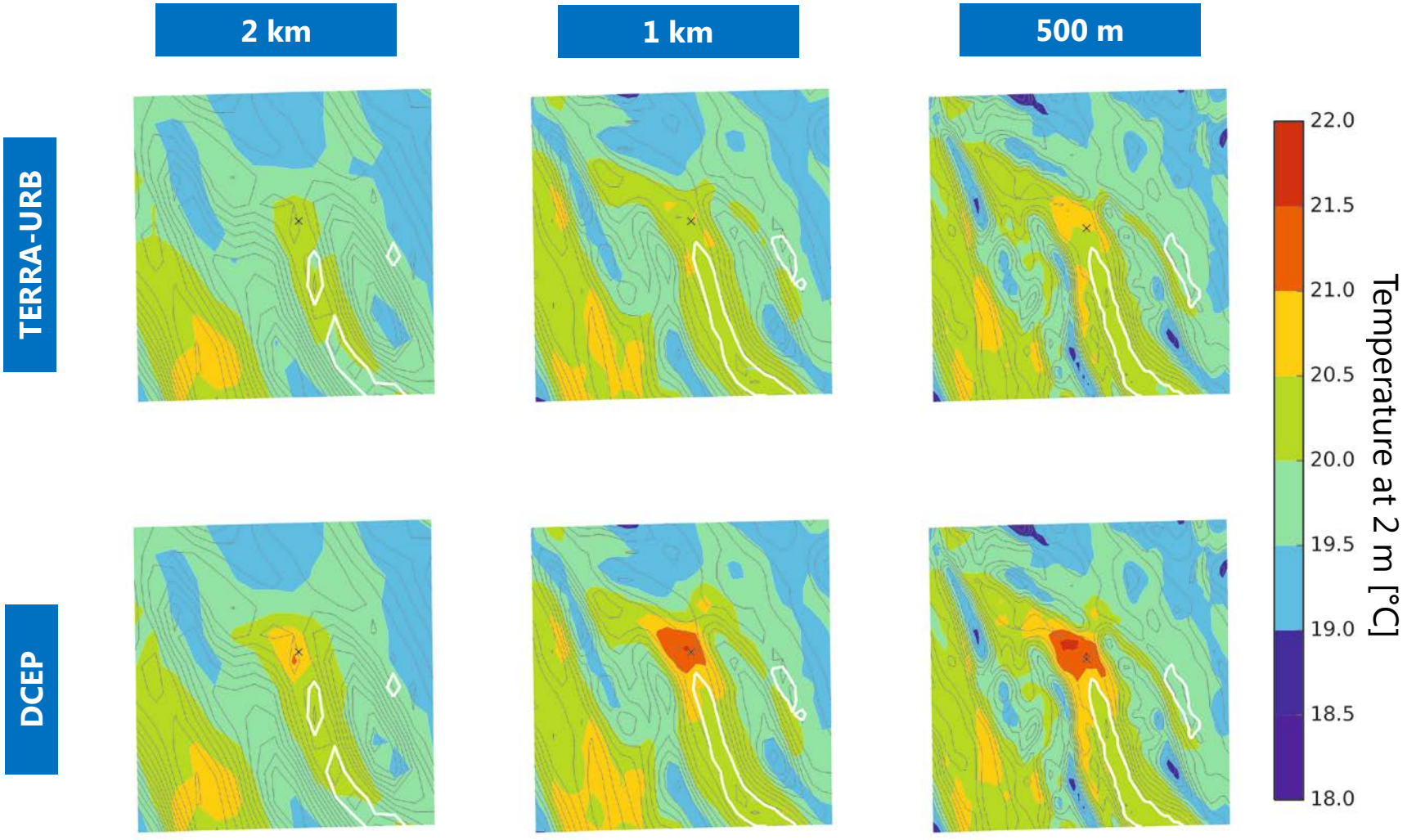
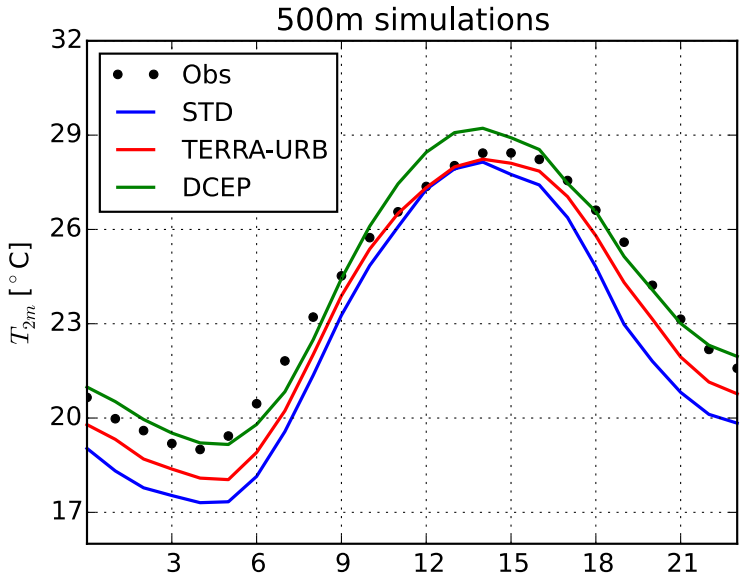
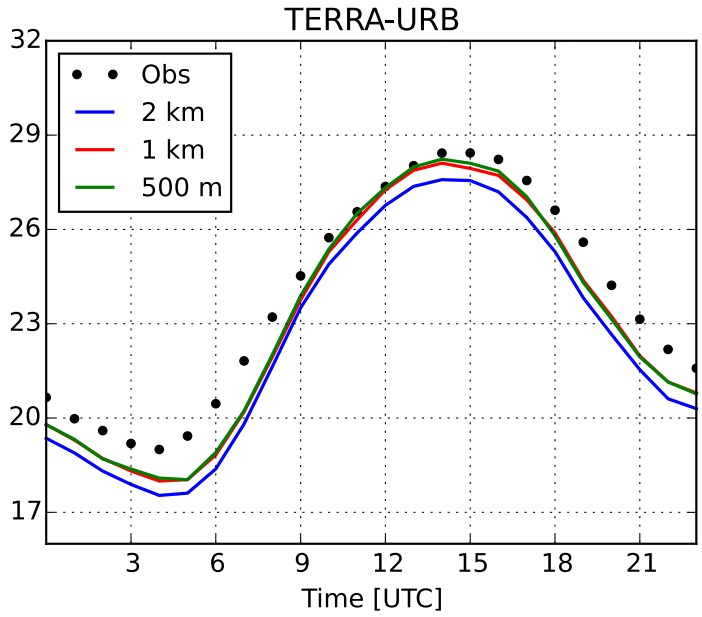
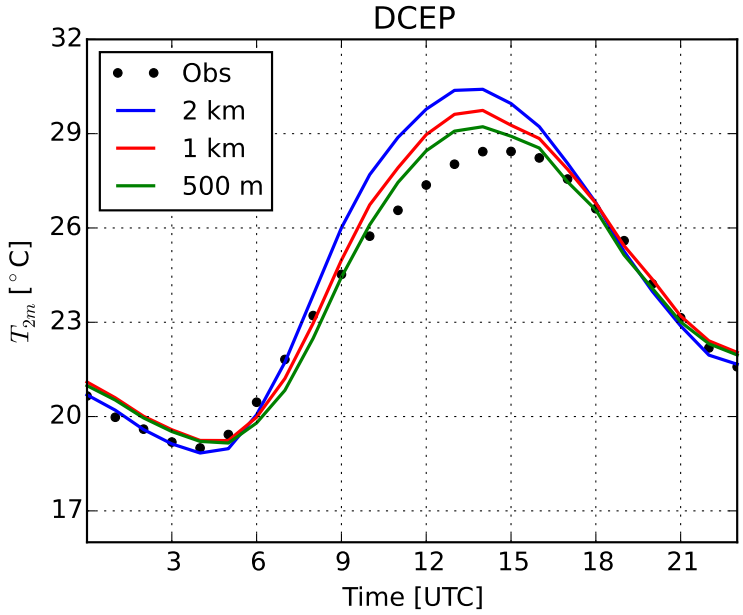


Time = 00 UTC, period averaged

Daily profile of T2 at KAS







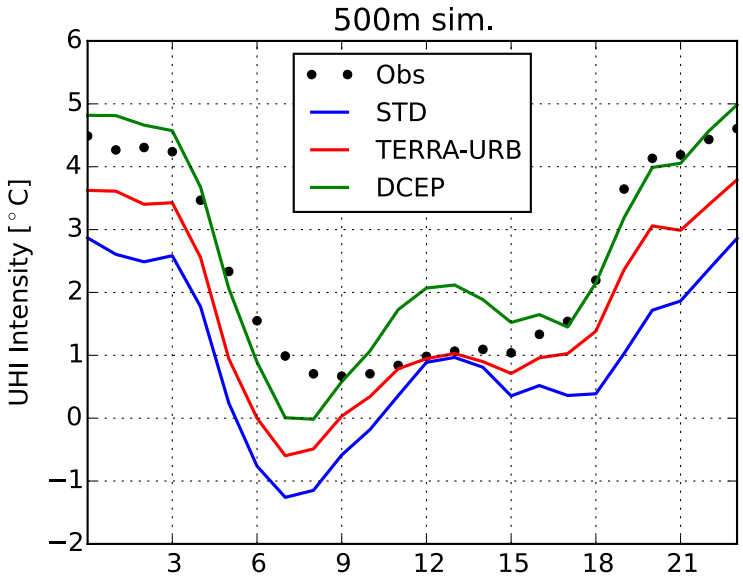
TERRA-URB

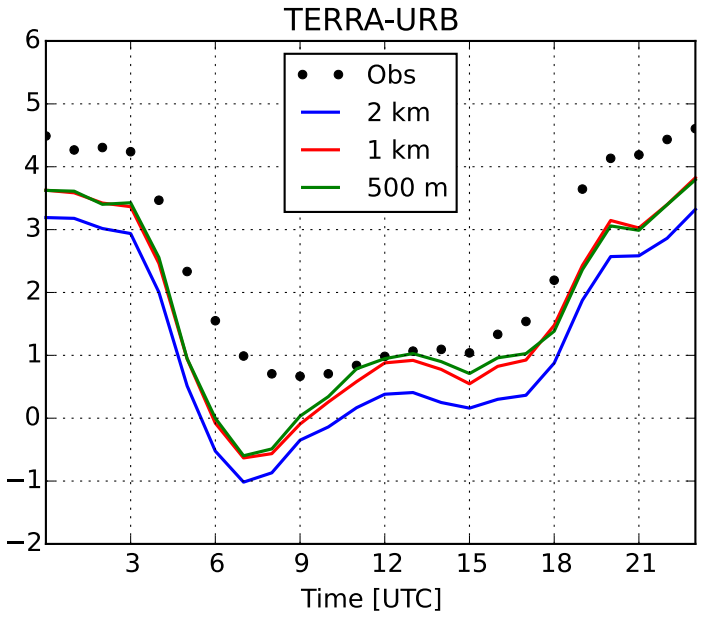
- Improvemet from 2 km to 1 km

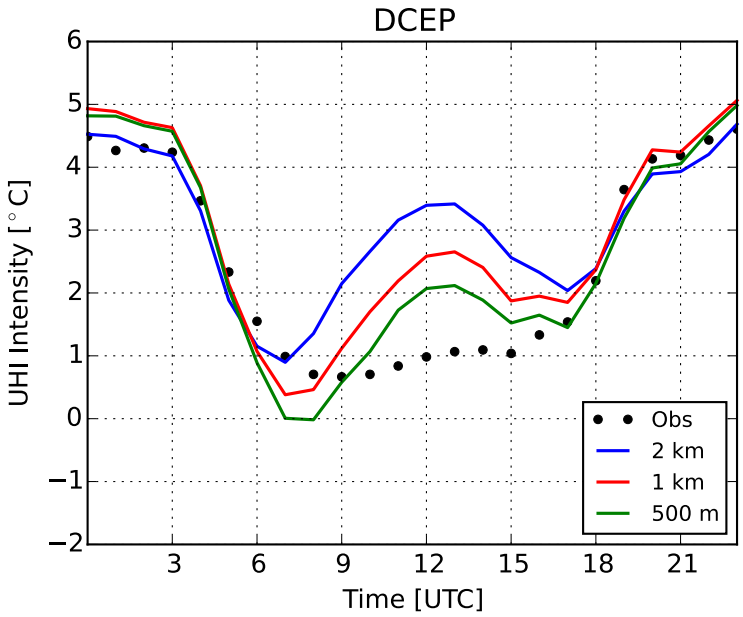
DCEP

- Overestimates daytime T
- Improves linearly with resolution

UHI Intensity (COSMO_T2_KAS – T2_KLO)







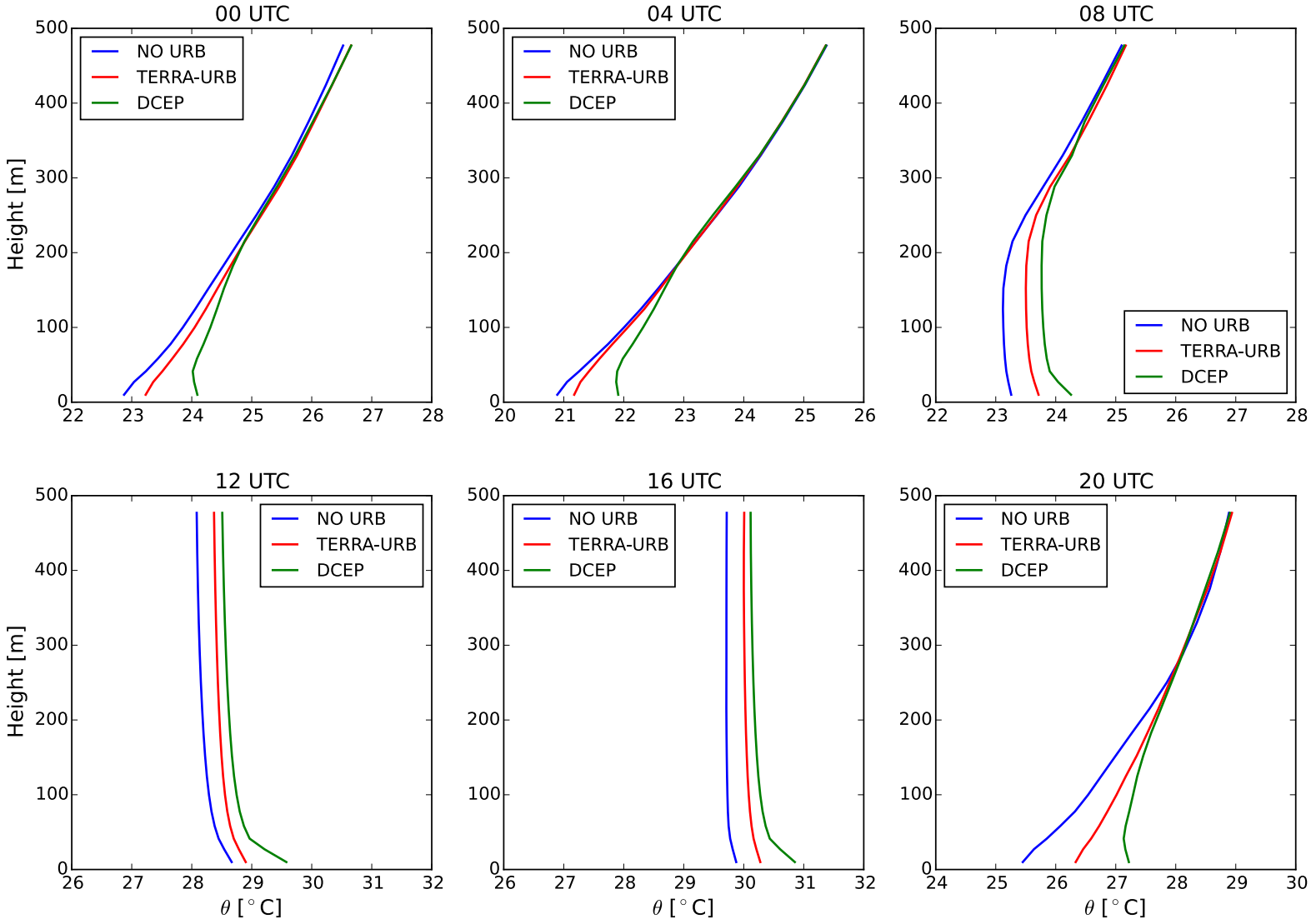
Day-time

- Too strong heating (afternoon)
- Overestimation in DCEP

Night-time

- Evolution well captured
- Underestimation in TERRA-URB

Profiles of potential temperature at KAS (no observations)



Summary

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- CCLM used at various model resolution
- Heat wave event 2015 in Switzerland
- Urban canopy model of various complexity compared
  - TERRA-URB (bulk scheme)
  - DCEP (multi-layer)
- Impact of model resolution
- Impact of urban parameterization

Conclusions

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- Model resolution affects extension and magnitude of UHI
  - Small scale features resolved
  - Mosaic approach interesting?
- Model resolution impacts on the model performance
  - TERRA-URB: from 2 km to 1 km resolution
  - DCEP: linear improvements from 2 km to 500 m
- Remarks
  - Sensitivity to urban surface and morphologic parameters
  - Sensitivity to urban vegetation (DCEP)
  - Further urban observations required (surface and vertical)

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Thank you for your attention

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