Model capability to reproduce urban heat island and implications for air quality assessment

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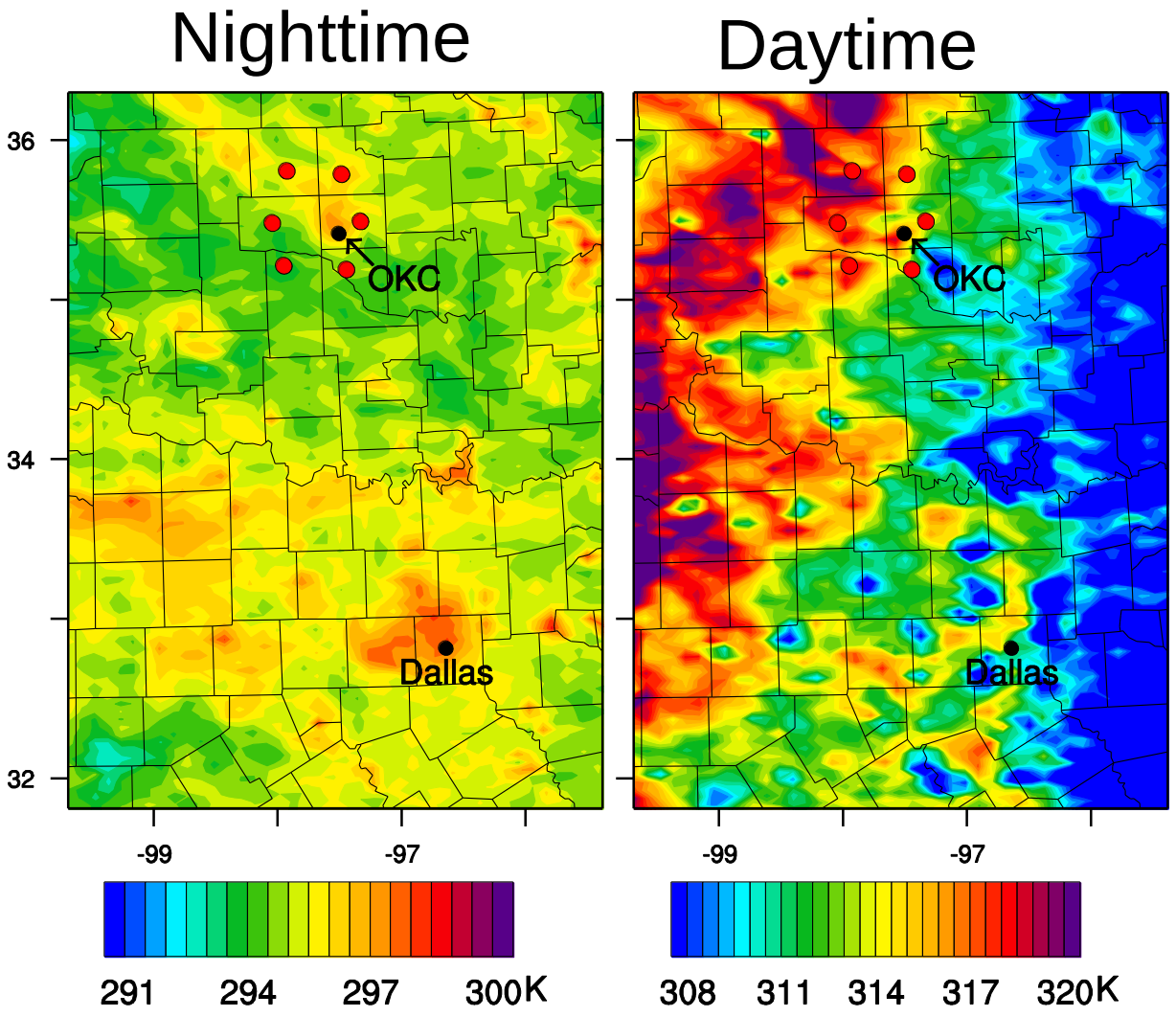
10AM, Nov. 19, 2013

at UEP conference

MODIS-derived land surface temperature

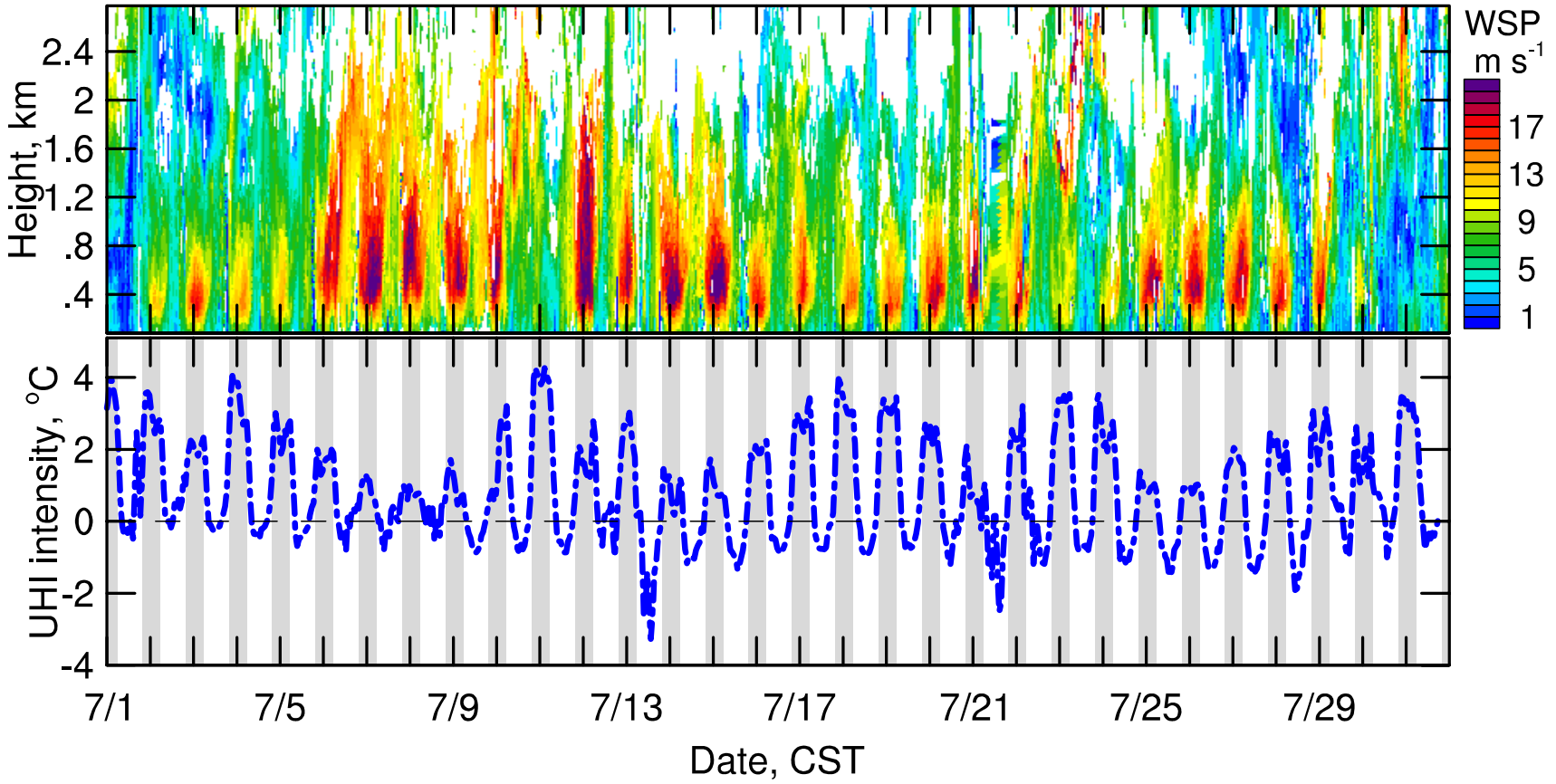


Hu et al. (2013a, JAMC)

Red dots around OKC:
Six rural sites

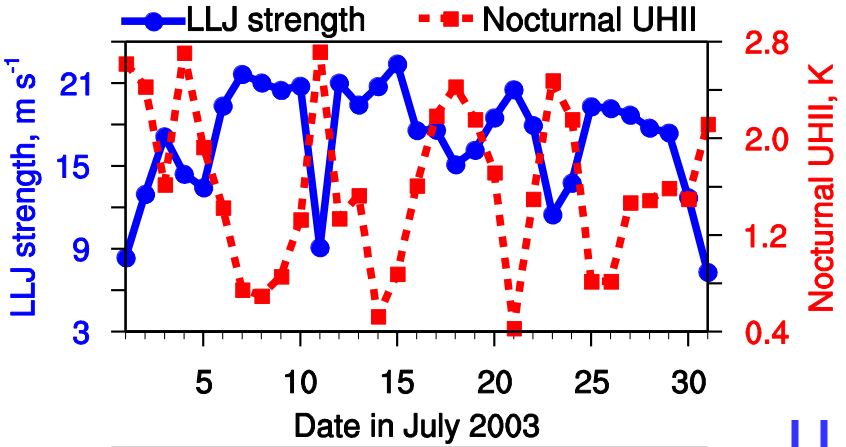
UHI is prominent during the nighttime. Nocturnal LLJs occur frequently in this region, must play some roles.

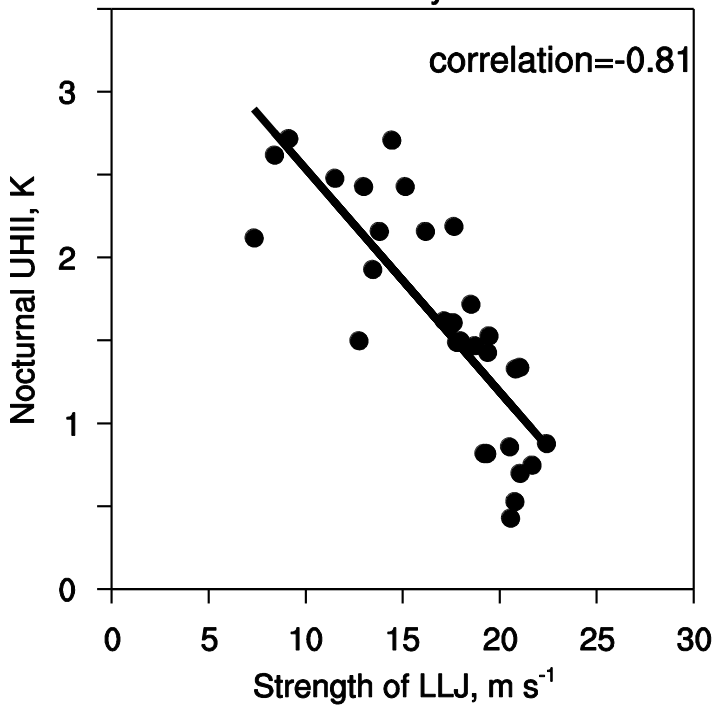
LLJs modulate variation of nocturnal UHI intensity in OKC



UHI intensity: T difference at 2m between urban and rural area

Relationship between LLJs and nocturnal UHI intensity



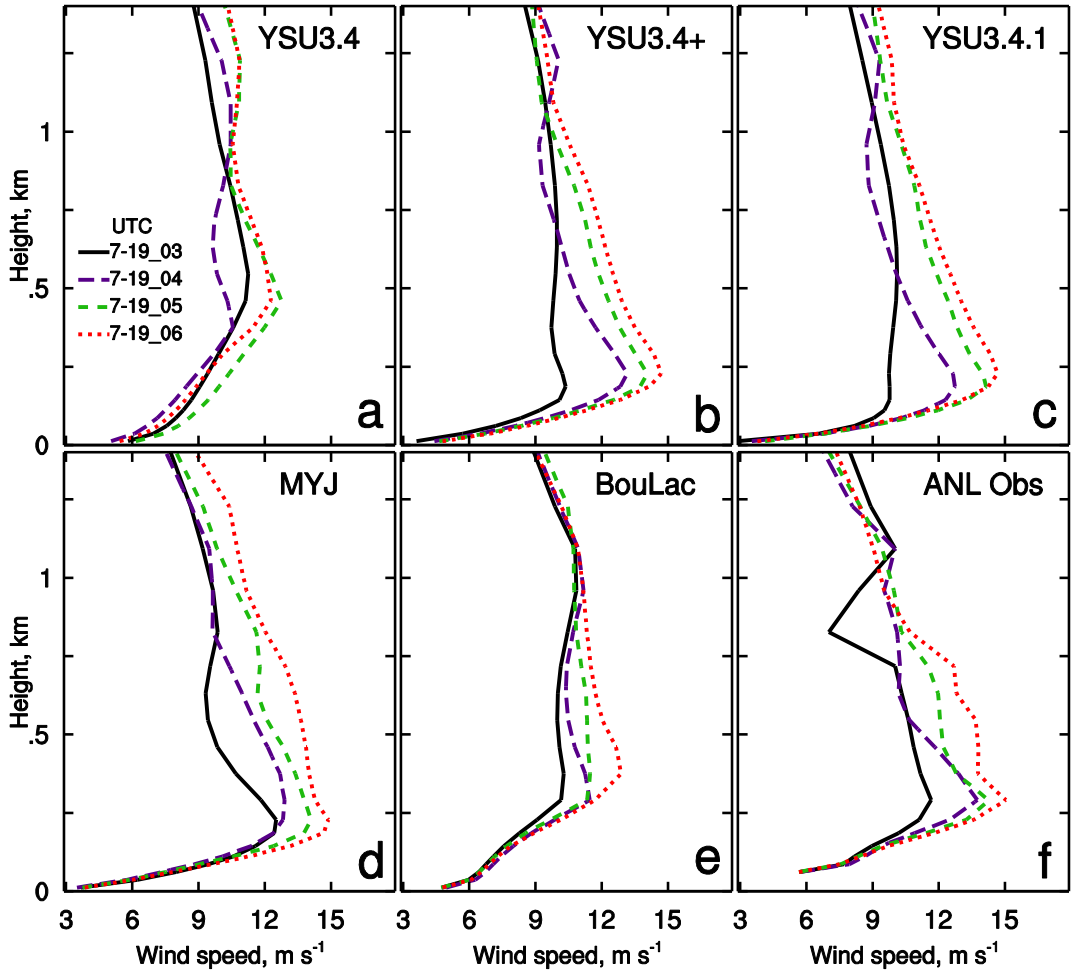


LLJ strength: maximum wind speed of a LLJ

Nocturnal UHII: mean T difference between urban and rural area during nighttime

LLJs modulate nocturnal UHI intensity

Different boundary layer schemes simulate different LLJs

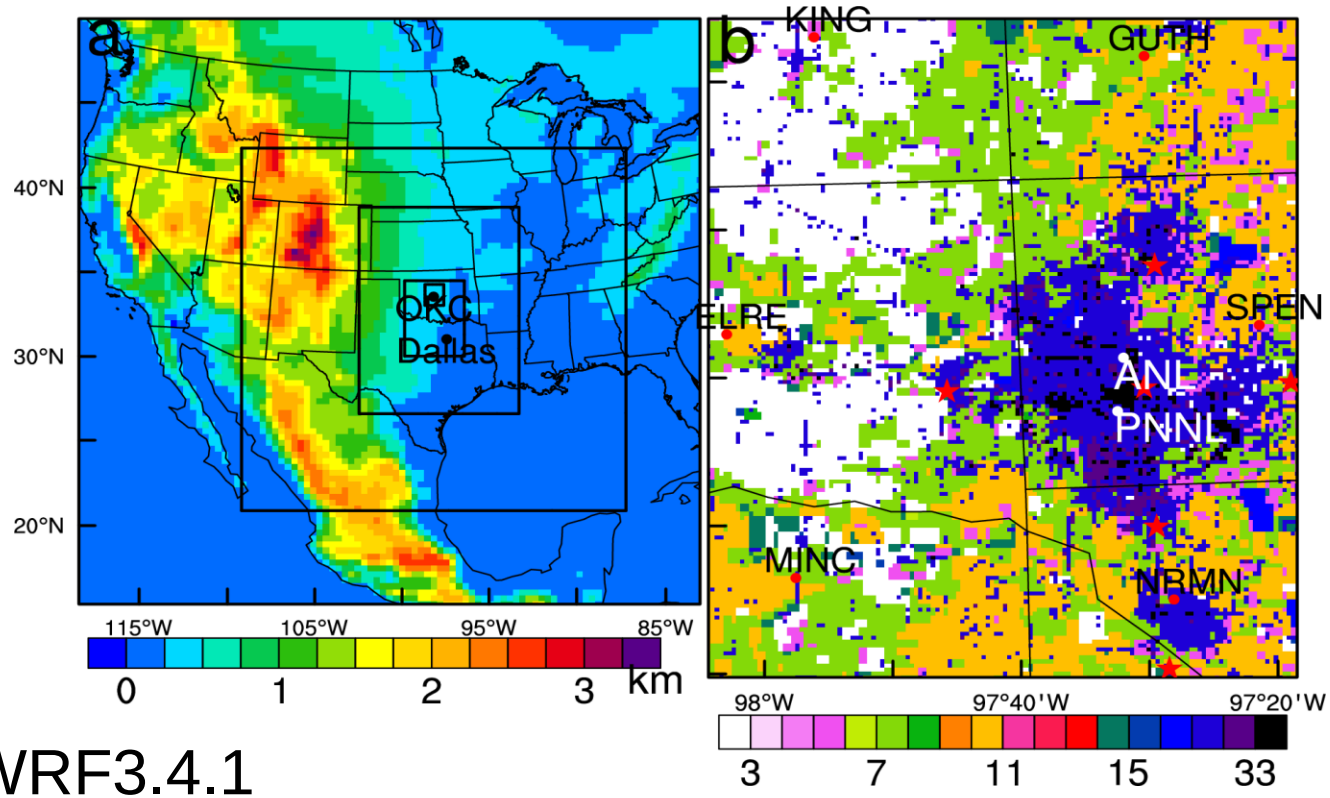


Hu et al. (2013b, JGR)

Objectives of this study

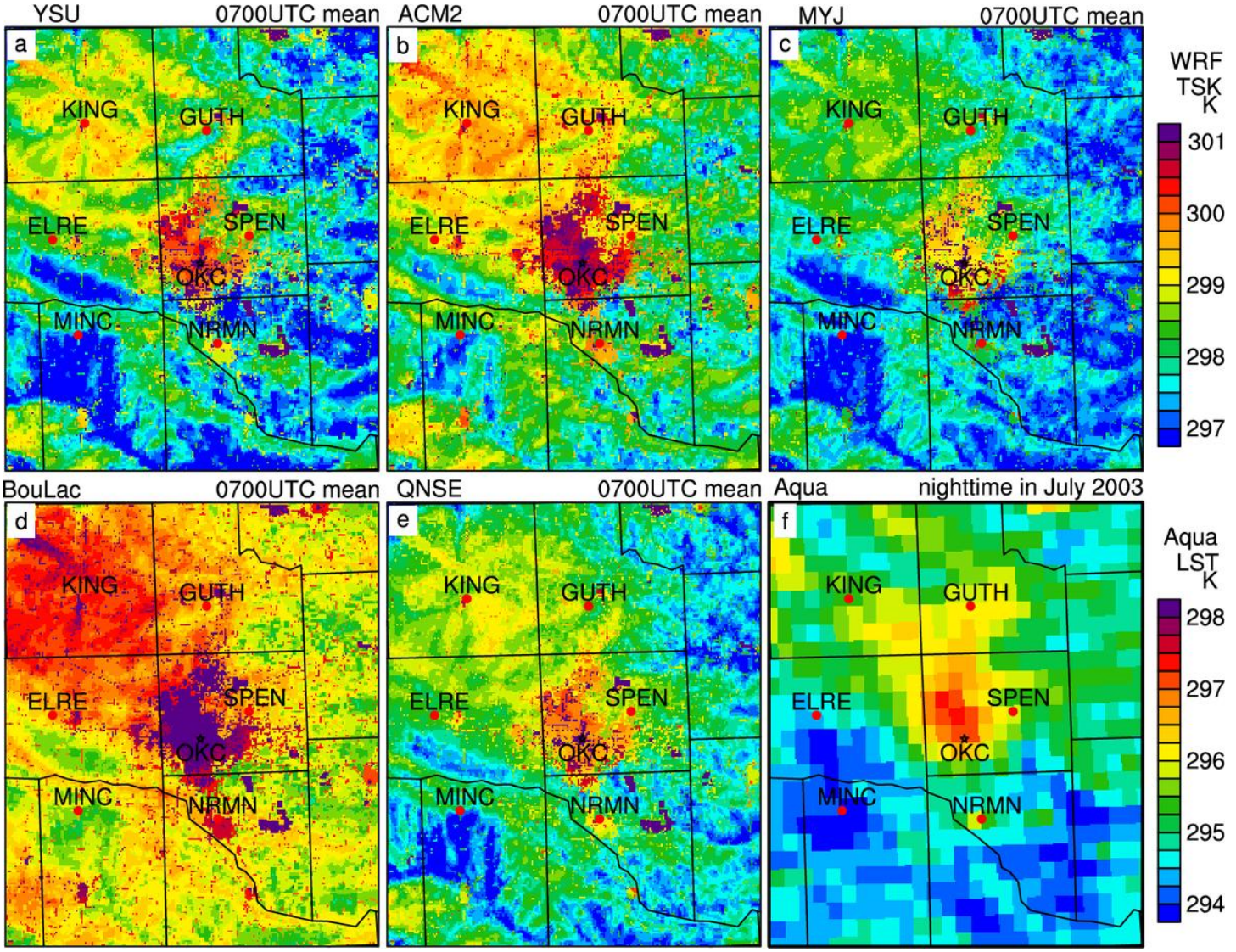
- **Investigate WRF model capability to reproduce UHI with different boundary layer schemes**
- **Examine the diurnal variation of UHI and its reasons**
- **Discuss the implications for air quality assessments**

Model domains and configurations



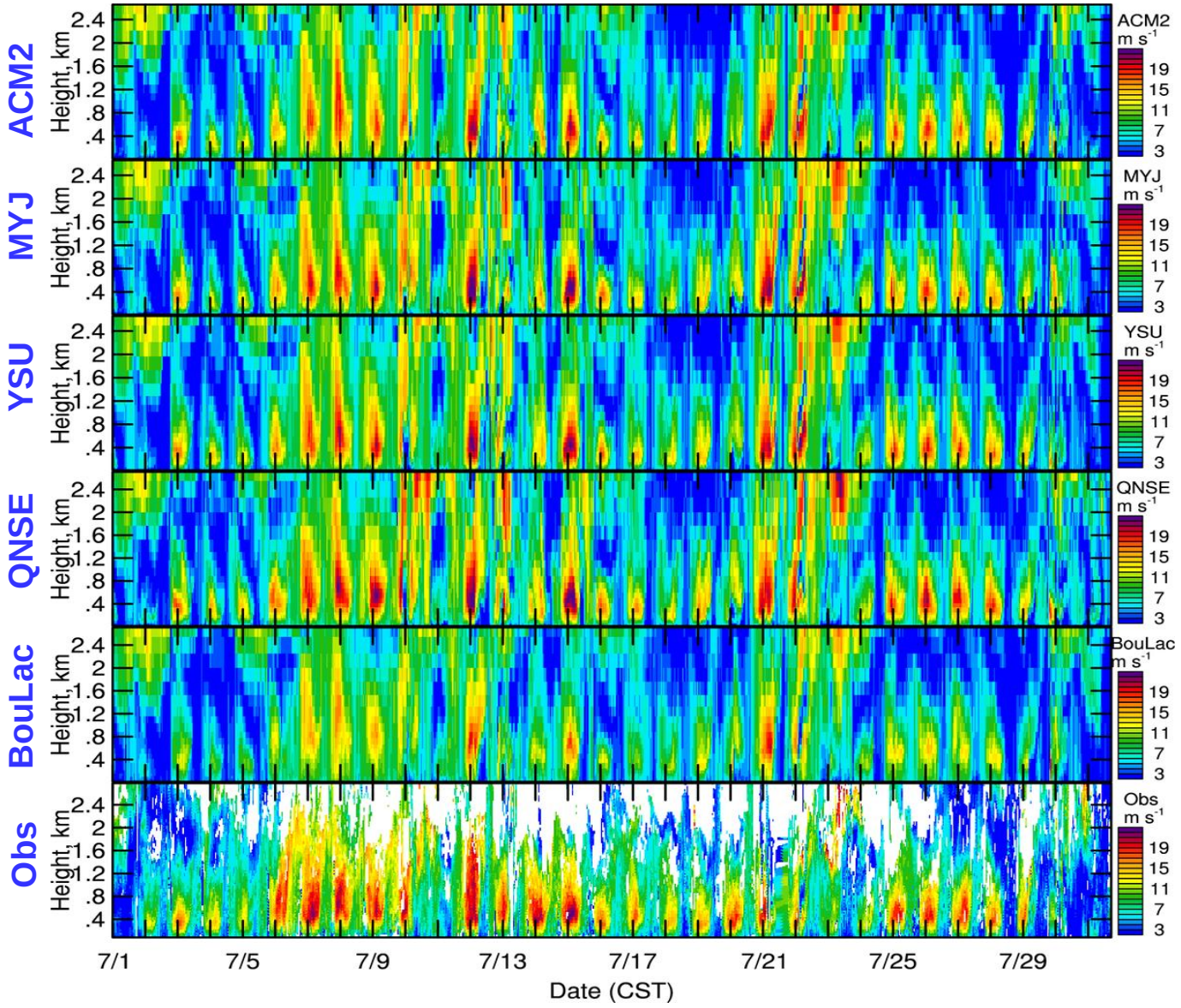
- WRF3.4.1
- 40.5->13.5->4.5->1.5->0.5km
- NOAH+Urban canopy model
- Boundary layer scheme: YSU, ACM2, MYJ, BouLac, QNSE
- Simulation period: July 2003
- ACM2 PBL scheme
- NARR for IC/BC

Monthly mean skin temperature



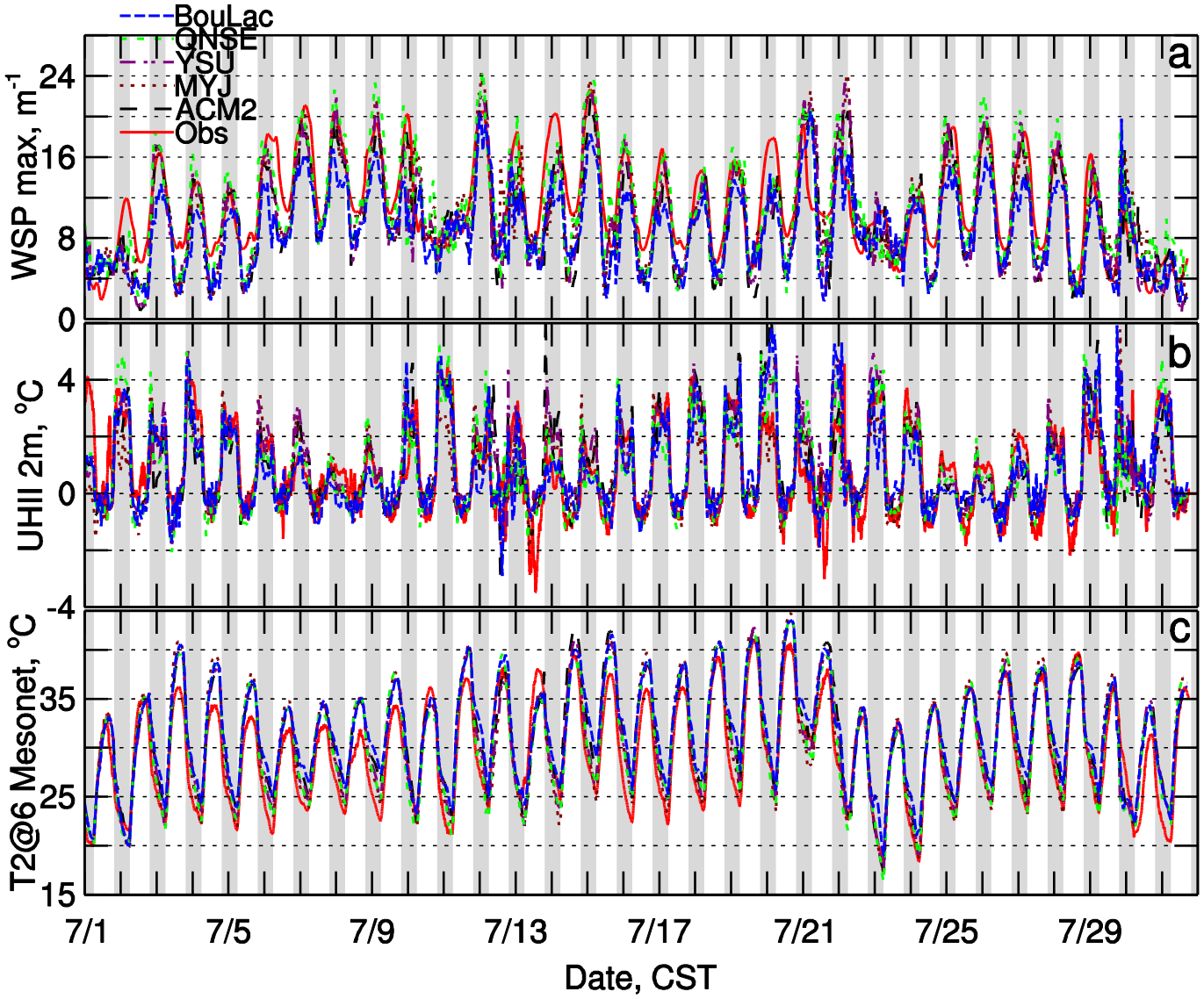
Model reproduces the spatial extent

Performance of boundary layer wind speed



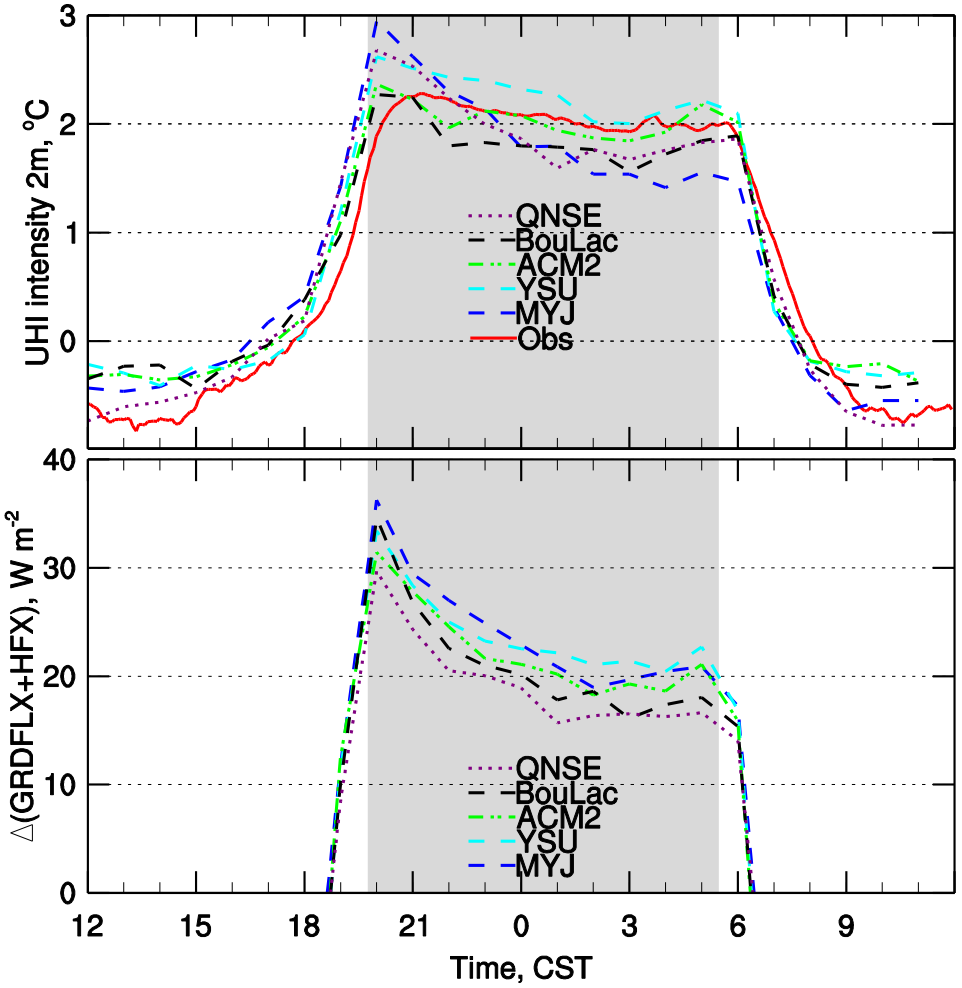
BouLac underestimates LLJ strength

Performance of wind, UHI intensity, T



WRF model captures the day-to-day variation of UHI intensity

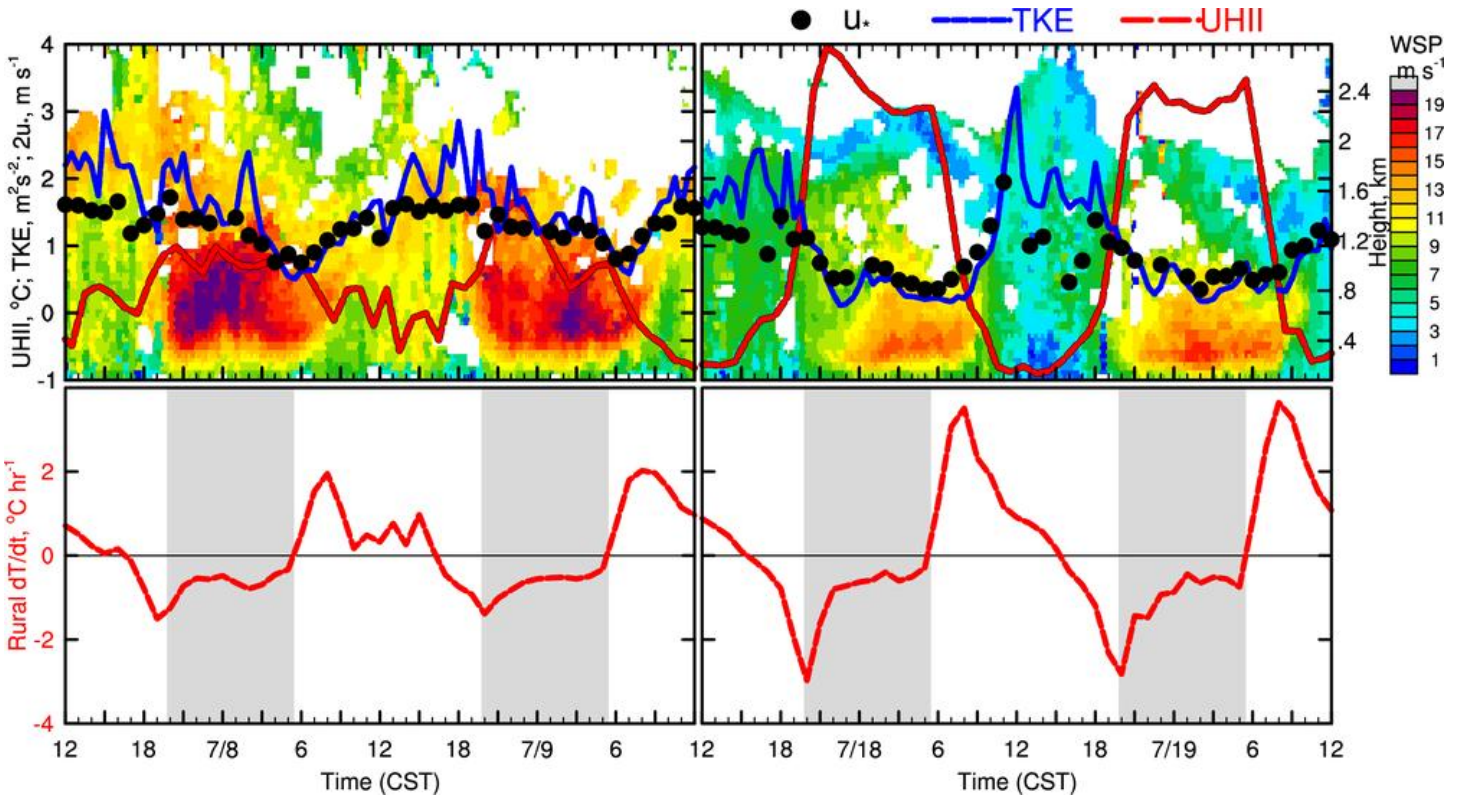
Mean diurnal variation of UHI intensity



Ground flux and sensible heat flux modulated the hourly variation of UHI intensity

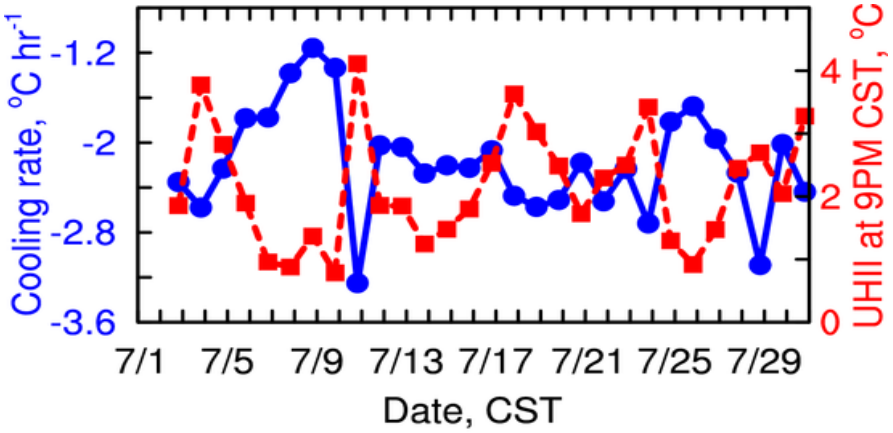
Two contrasting episodes

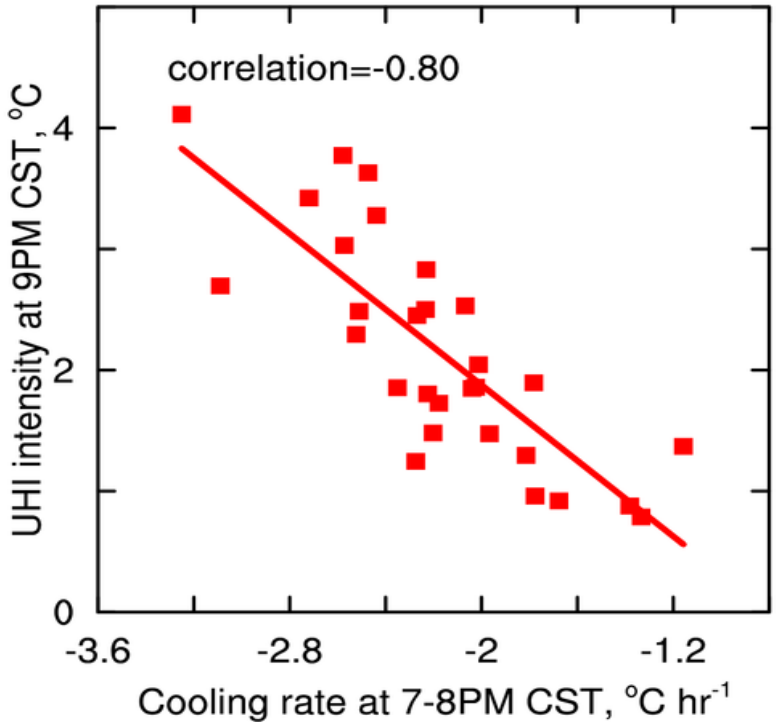
Strong LLJ, weak UHI **Weak LLJ, strong UHI**



Strong LLJ=>strong turbulence=>strong coupling/downward heat flux =>small cooling rate=>weak UHI

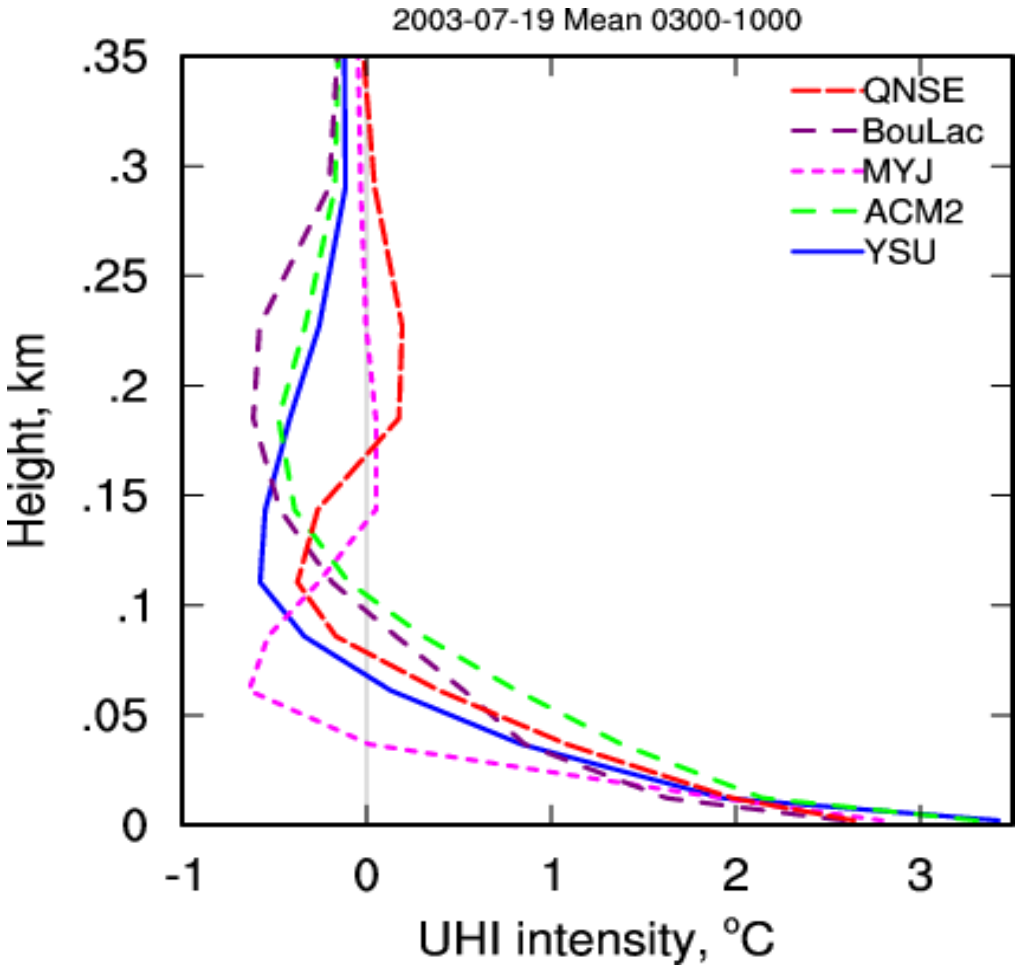
Relationship between rural cooling rate and UHI intensity





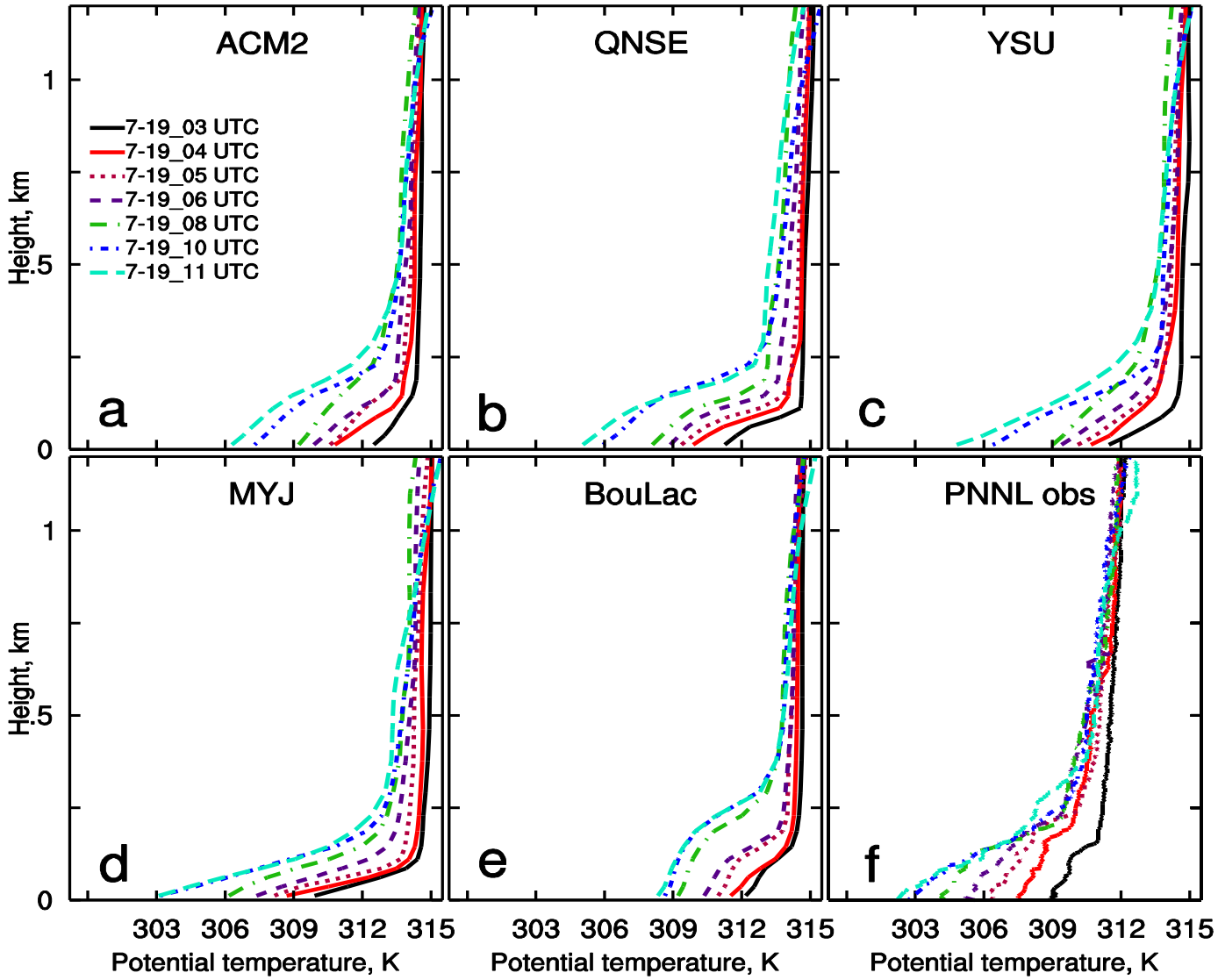
Rural cooling rate during the early evening transition is a good indicator of nocturnal UHI intensity

Vertical extent of UHI intensity



Different boundary layer schemes simulate different vertical extent of UHI.
Such uncertainty of UHI vertical extent may be related to biases of simulated pollutants in urban region during nighttime.

Performance of vertical T profile



Different boundary layer schemes have different vertical mixing strength

Conclusions

1. LLJs paly an important role in modulating the nocturnal UHI intensity.
2. Rural cooling rate during the EET plays a critical role in regulating nocturnal UHII
3. Different boundary layer schemes simulate different vertical extent of UHI, which is important for air quality assessments in urban region.

References

1. **Hu, X.-M.**, P. M Klein, M. Xue, J. K. Lundquist, F. Zhang, and Y., Qi (2013a), Impact of Low-Level Jets on the Nocturnal Urban Heat Island Intensity in Oklahoma City. *J. Appl. Meteor. Climatol.*, 52, 1779–1802.
2. **Hu, X.-M.**, P. M. Klein, and M. Xue (2013b), Evaluation of the updated YSU planetary boundary layer scheme within WRF for wind resource and air quality assessments, *J. Geophys. Res. Atmos.*, 118, 10,490–10,505, doi:10.1002/jgrd.50823.
3. **Hu, X.-M.** , P. M. Klein, M. Xue (2013c) Coupling in the nocturnal boundary layer in the presence of low-level jets in Oklahoma, to be submitted.