

Validating WRF surface variables in Houston using the BULK and SLUCM Schemes

James Brownlee and Pallav Ray

Department of Marine and Environmental Systems (DMES)

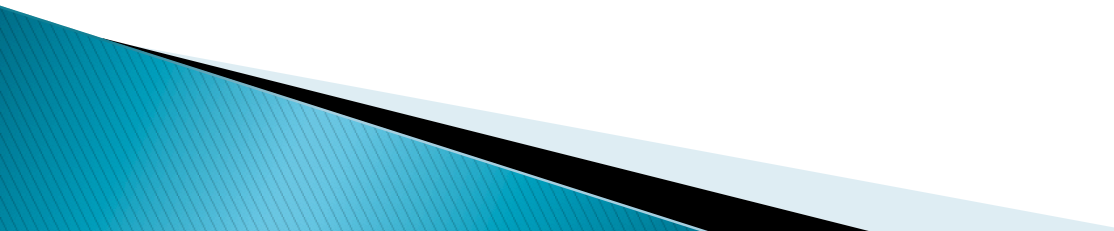
Florida Institute of Technology (FIT)

Mukul Tewari

National Center for Atmospheric Research (NCAR)



Outline of Talk

- ▶ 1. Model Configuration
 - ▶ 2. Urban Land Use and Station Locations
 - ▶ 3. Analysis of Temperatures and Wind Speeds at each Station
 - ▶ 4. Surface Heat Fluxes at each Station
 - ▶ 5 Conclusion
- 

Model Configuration

Run Details

Time Step: 30s

Start: 08/24/2000 at 00UTC

End: 08/26/2000 at 18UTC

Lat: 29.562 Lon: -95.742

Number of Simulations: 5

WRF-ARW V3.6

Domain 1

Dimensions: 104x106x35

Resolution: 9 km

Domain 2

Dimensions: 190x196x35

Resolution: 3 km

Domain 3

Dimensions: 280x262x35

Resolution: 1 km

Physics Options

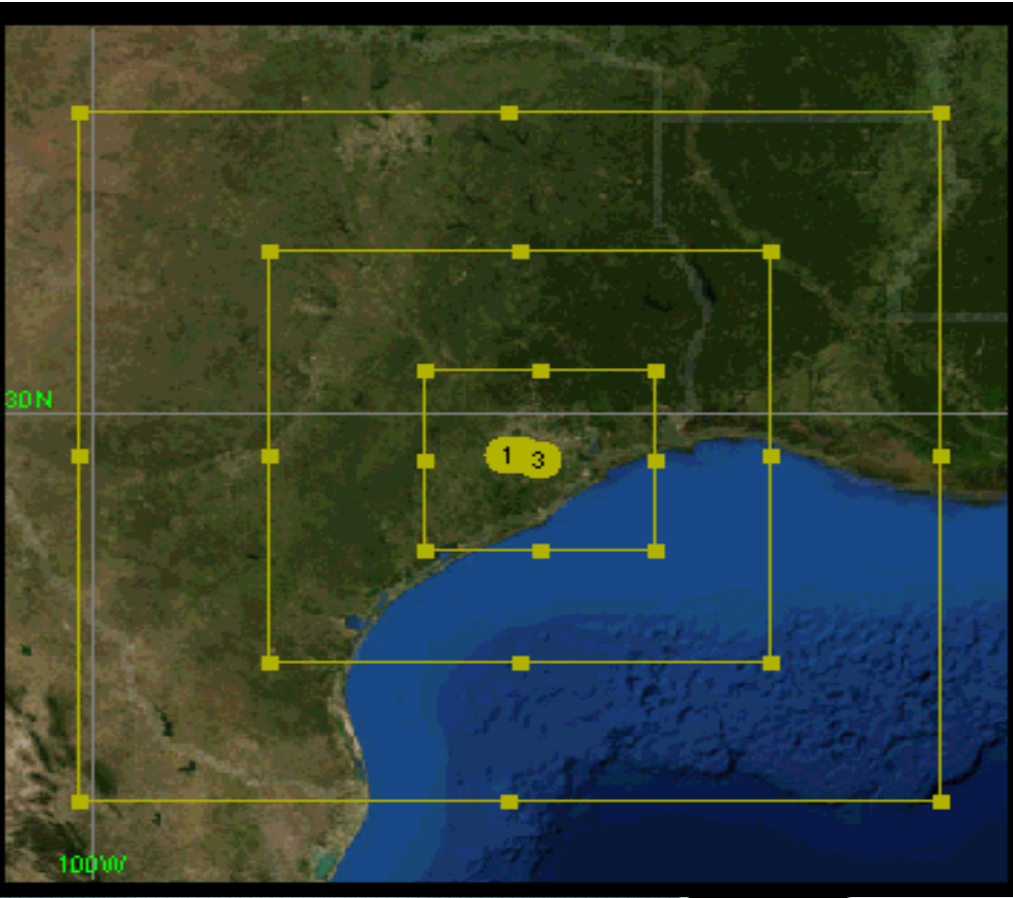
sf_surface_physics: NOAH LSM

bl_pbl_physics: YSU, MYJ,
MYNN2, and BOULAC

sf_urban_physics : BULK and
SLUCM

ra_lw_physics: RRTM

ra_sw_physics: Dudhia

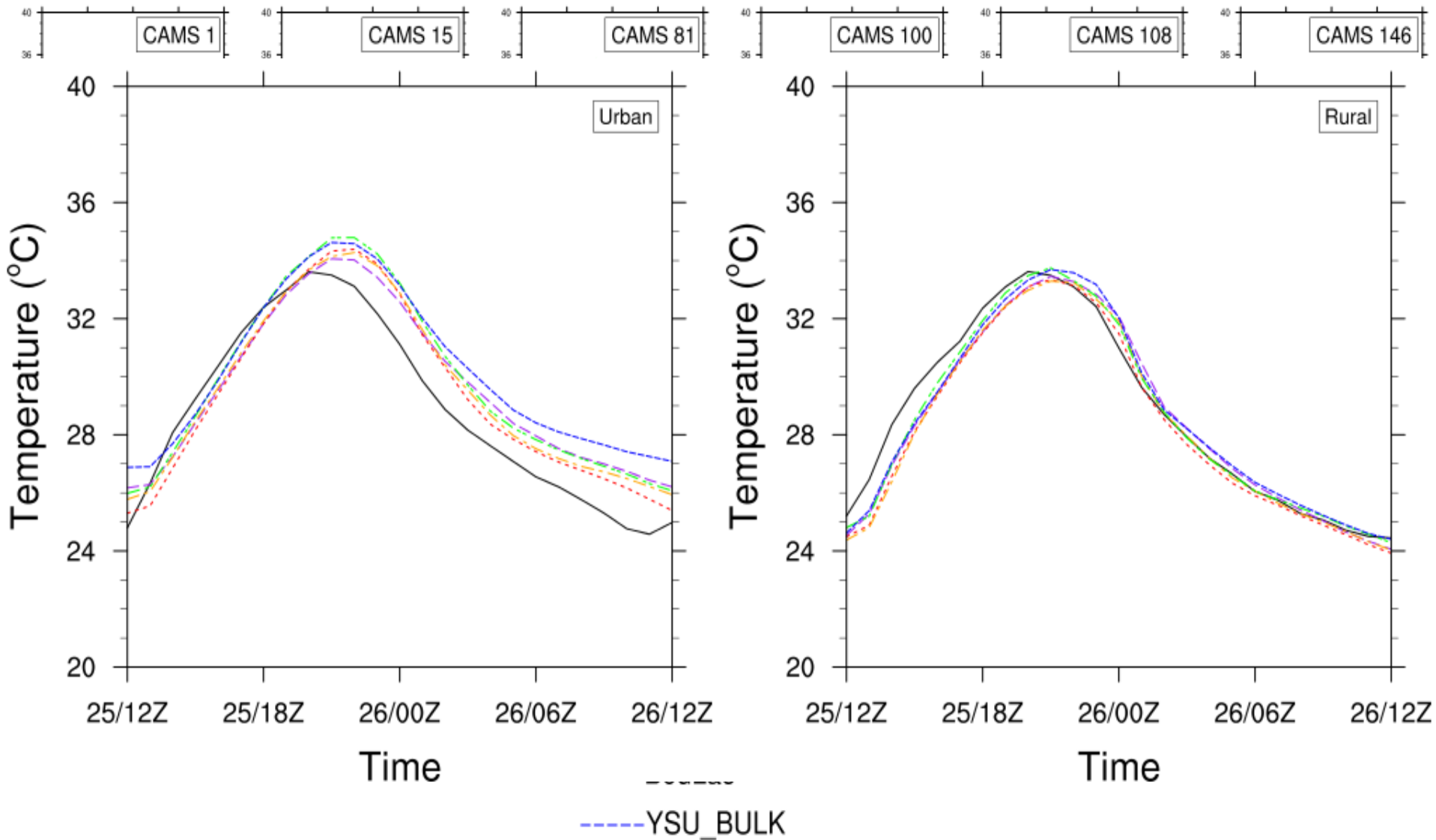


TCEQ Stations and Urban Land Use

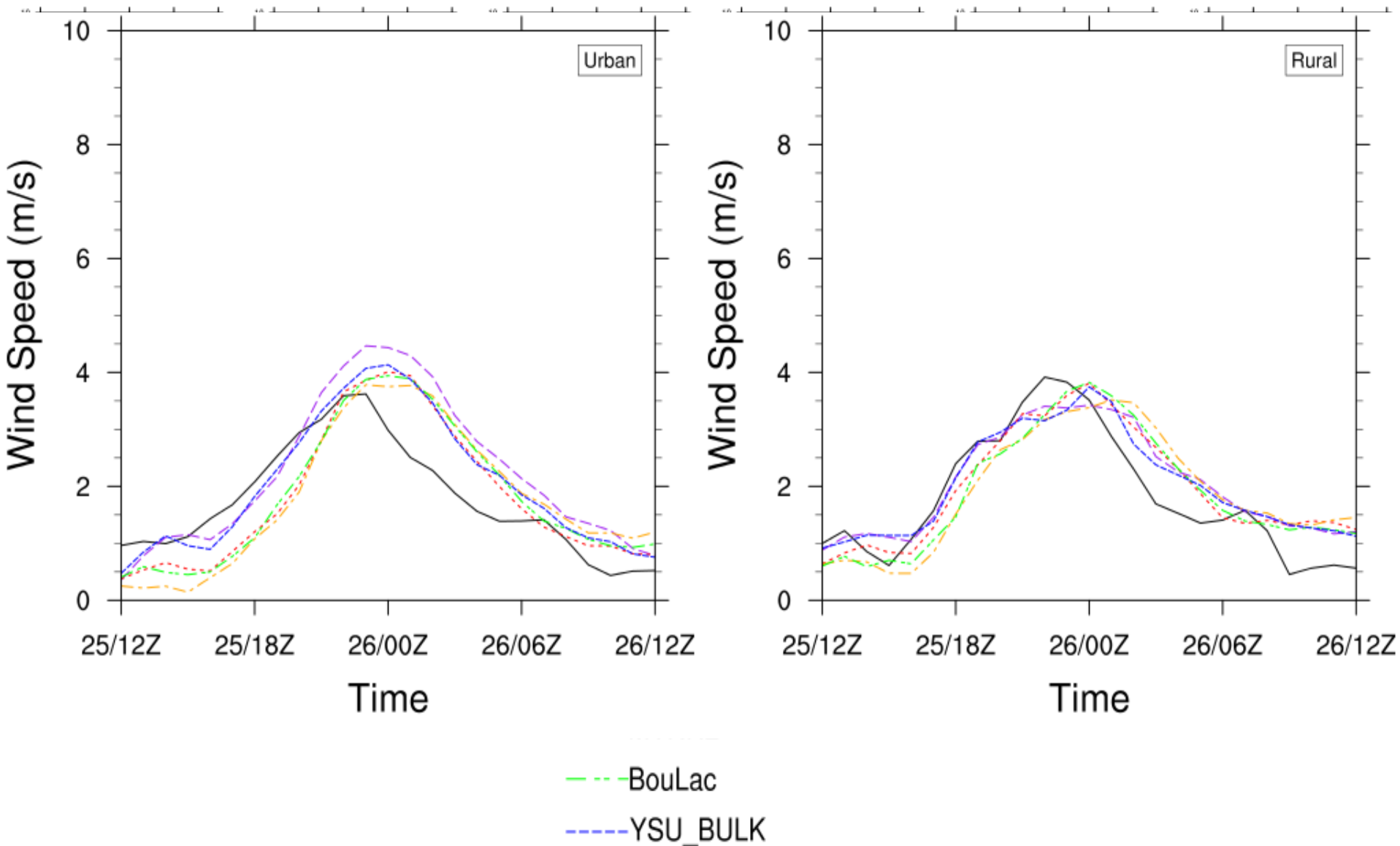
Land Use Categories 31-33

	Station ID	Latitude	Longitude	Land Category
	CAMS 1	29.7681	-95.2206	LIR
	CAMS 11	29.0111	-95.3975	RUR
	CAMS 15	29.8025	-95.1256	LIR
	CAMS 26	30.0395	-95.6739	RUR
	CAMS 48	29.9478	-95.5431	RUR
	CAMS 51	29.6131	-95.1733	RUR
29	CAMS 81	29.7355	-95.3156	HIR
	CAMS 100	29.3900	-94.9194	COI
29	CAMS 108	29.9010	-95.3261	LIR
	CAMS 146	29.6957	-95.4992	HIR
	CAMS 153	29.6690	-95.1280	RUR
29	CAMS 167	29.7342	-95.2383	COI
	CAMS 169	29.7062	-95.2611	LIR
29	CAMS 403	29.7336	-95.2575	COI
	CAMS 404	29.8069	-95.2847	COI
	CAMS 409	29.6239	-95.4742	LIR
	CAMS 410	29.7233	-95.6358	RUR
	CAMS 603	29.7653	-95.1811	COI

Temperature



Wind Speed

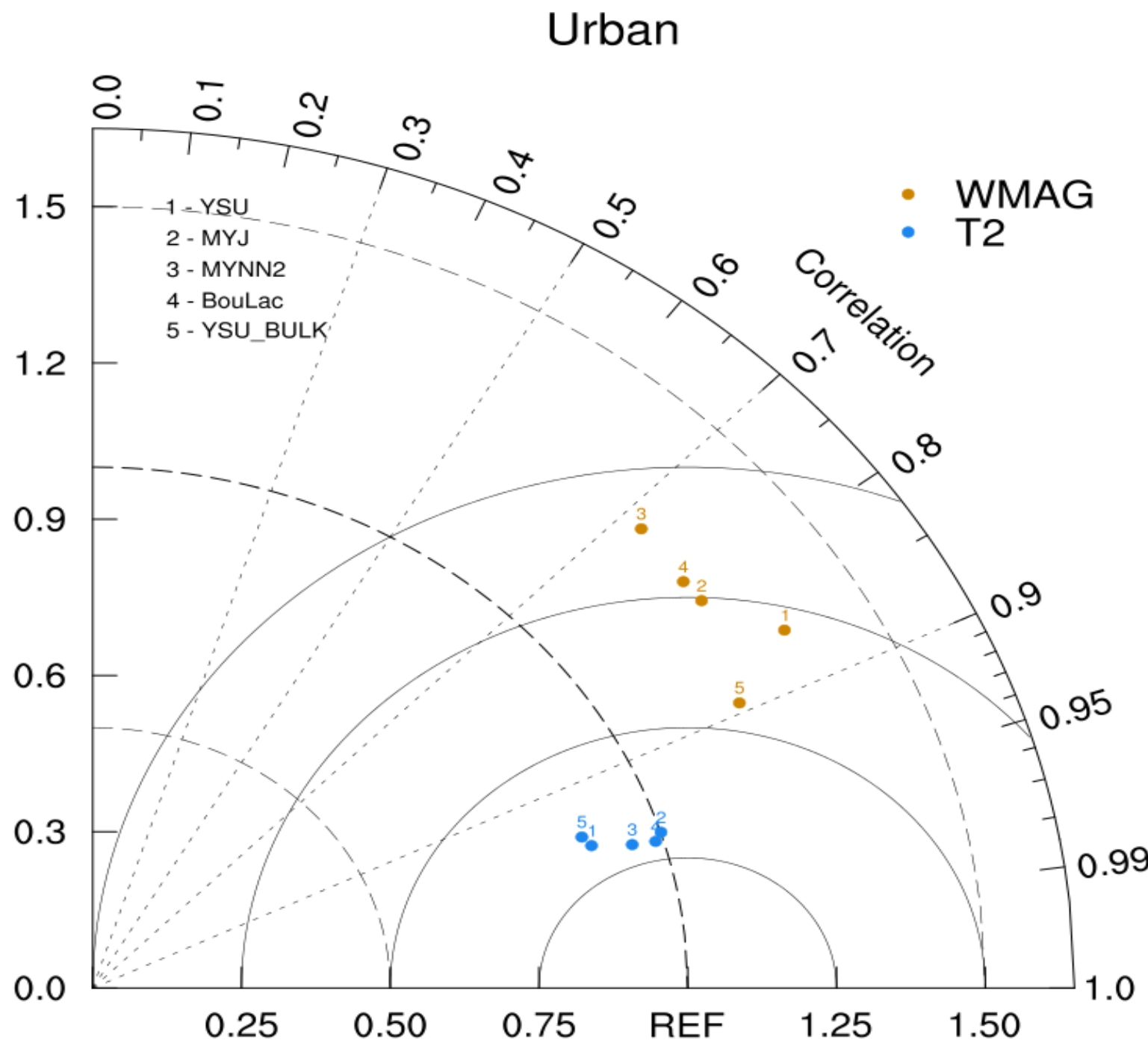


Urban

Standardized Deviations (Normalized)

YSU

Standardized Deviations (Normalized)



Standardized Deviations (Normalized)

YSU

Standardized Deviations (Normalized)

Standardized Deviations (Normalized)

Rural

WMAG
T2

Correlation

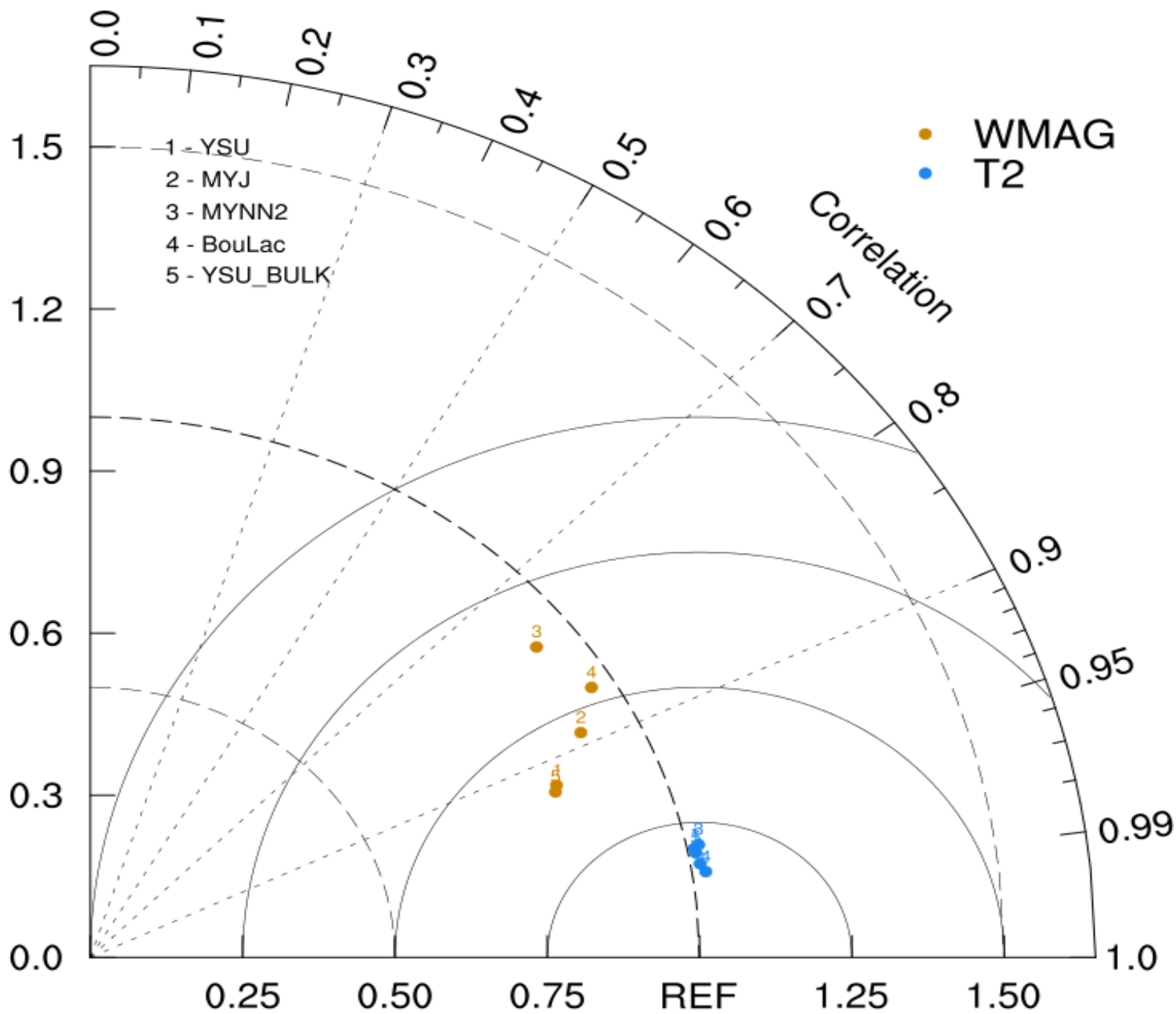
Standardized Deviations (Normalized)

- 1 - YSU
- 2 - MYJ
- 3 - MYNN2
- 4 - BouLac
- 5 - YSU_BULK

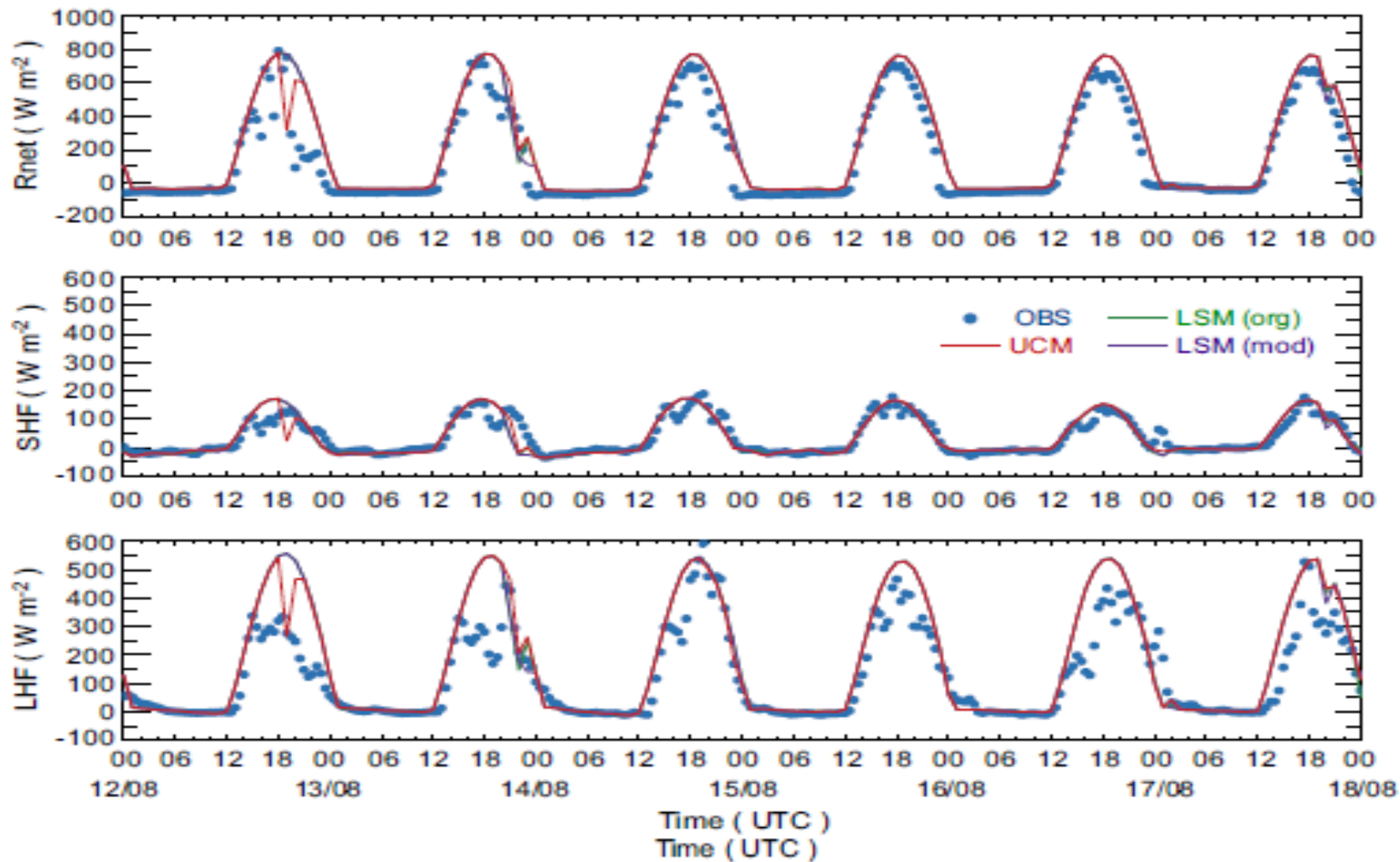
YSI

S

R



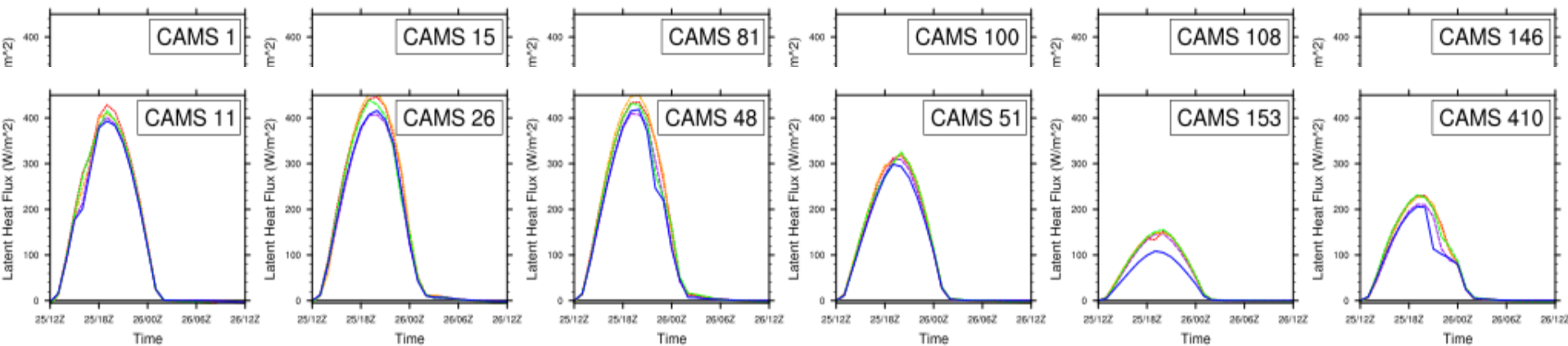
- ▶ Why do the BULK and SLUCM schemes over estimate the wind speed and temperature in the city?
- ▶ Studies have shown that within urban regions urban schemes like the BULK and SLUCM underestimate the LH fluxes at the surface and overestimate the SH fluxes (Grimmond et al., 2010, 2011) (Miao and Chen, 2014)
- ▶ This leads to an enhancement of the UHI in the city, which further leads to enhanced vertical mixing, increased near surface winds, and an increase in the PBL height (Chen et al., 2011) (Grimmond et al., 2010, 2011) (Miao and Chen, 2014)
- ▶ The increase in temperature also leads to increases in the surface SH fluxes (Miao and Chen, 2014)
- ▶ This scenario can occur in the model when the soil moisture content is low (Chen et al., 2011)
- ▶ It is known that urban schemes like the SLUCM oversimplify urban hydrological processes; this results in an underestimation of surface LH fluxes in the city (Yang et al., 2014)
- ▶ For example, the original SLUCM in WRF neglects LH fluxes from paved surfaces (Yang et al., 2014)



Model and observed surface heat fluxes at a BUR site in Houston during August 2006. (Figure taken from Lee et al., 2011)

Latent Heat Fluxes in the Model

Land Use Categories 31-33



--- YSU_BULK

--- BouLac

--- MYNN2

--- MYJ

--- YSU

--- MYNN2

--- MYJ

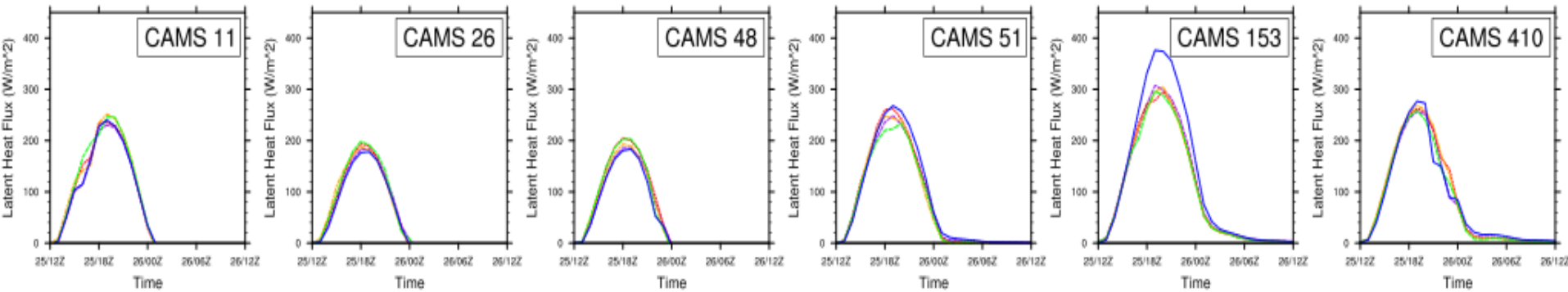
--- YSU



Sensible Heat Fluxes in the Model

Land Use Categories 31-33

Land Use Categories 31-33



--- YSU_BULK

--- BouLac

--- MYNN2

--- MYJ

--- YSU

--- BouLac

--- MYNN2

--- MYJ

--- YSU

Conclusion/Future Work

- ▶ The SLUCM and the BULK urban schemes both over estimate the near surface wind speeds and temperatures within Houston.
- ▶ The RMSE is larger at the stations within the city, this is most pronounced with the model's temperature predictions.
- ▶ It appears that the model is underestimating the latent heat fluxes at the urban stations.
- ▶ Low LH fluxes=not enough cooling=enhanced temperatures, wind speeds, and increased SH fluxes.
- ▶ Further testing is needed to prove if this is what is causing the over predictions of wind speed and temperature.
- ▶ Further tests should include increasing the soil moisture in the model (Chen et al., 2011) and rerunning all five simulations with the new SLUCM which has been released with WRF 3.7
- ▶ Studies have shown that this new SLUCM produces surface LH fluxes that are close to observations (Yang et al., 2014)

Conclusion/Future Work/ Acknowledgements

- ▶ The new SLUCM takes into account the following processes:
 - ▶ 1. evaporation from paved surfaces
 - ▶ 2. urban irrigation
 - ▶ 3. anthropogenic heat sources
 - ▶ 4. urban oasis effect
- ▶ With these more realistic urban hydrological processes, the model should be able to more accurately capture the near surface winds and temperatures in the city.
- ▶ Acknowledgements: Dr. Pallav Ray, Dr. Mukul Tewari, and Marcus Morgan