12th WRF Users' Workshop
20-24 June 2011

WRF Simulations of Seasonal Variations between the Surface and the Near-Surface Urban Heat Island

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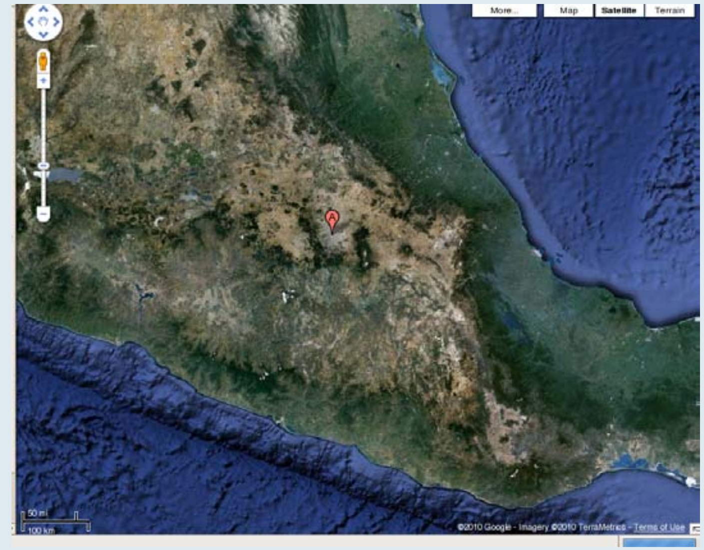
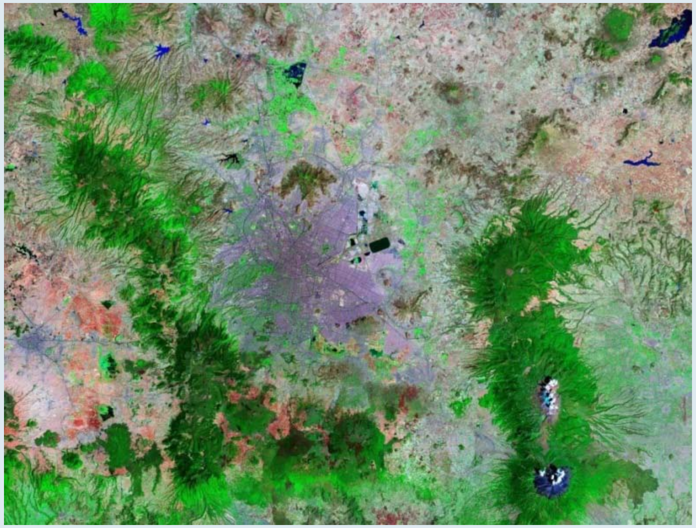
Mexico City

Second largest metropolitan area in the world.

- Tropical mountain climate with small annual temperature range.

- Dry and Wet seasons





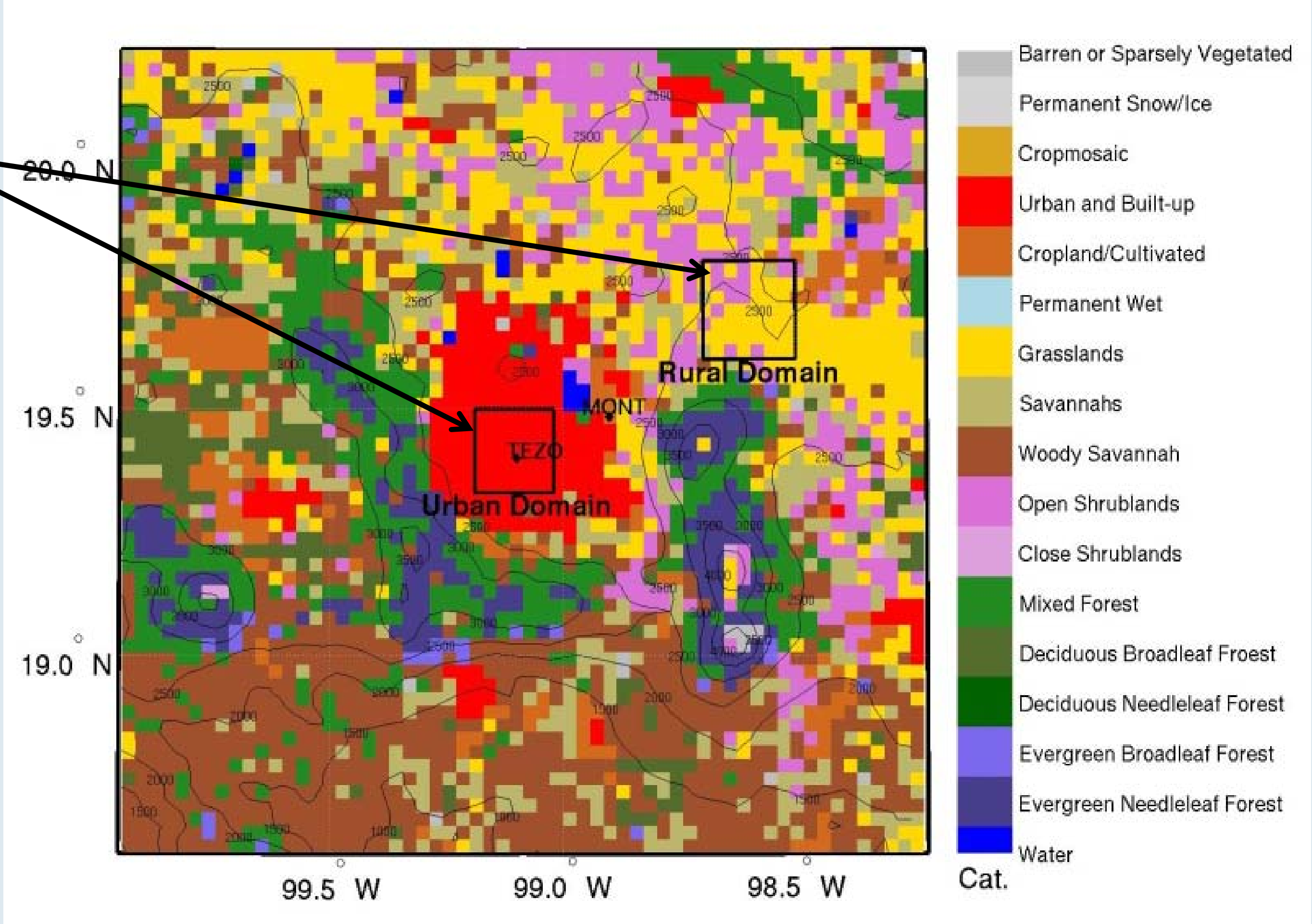
Outline

1. MODIS detect the seasonal behaviors of skin heat islands.
2. WRF configuration (MODIS).
3. Remote sensing + surface observations + simulations.
4. The relationship between vegetation fraction and heat islands.
5. Summary.

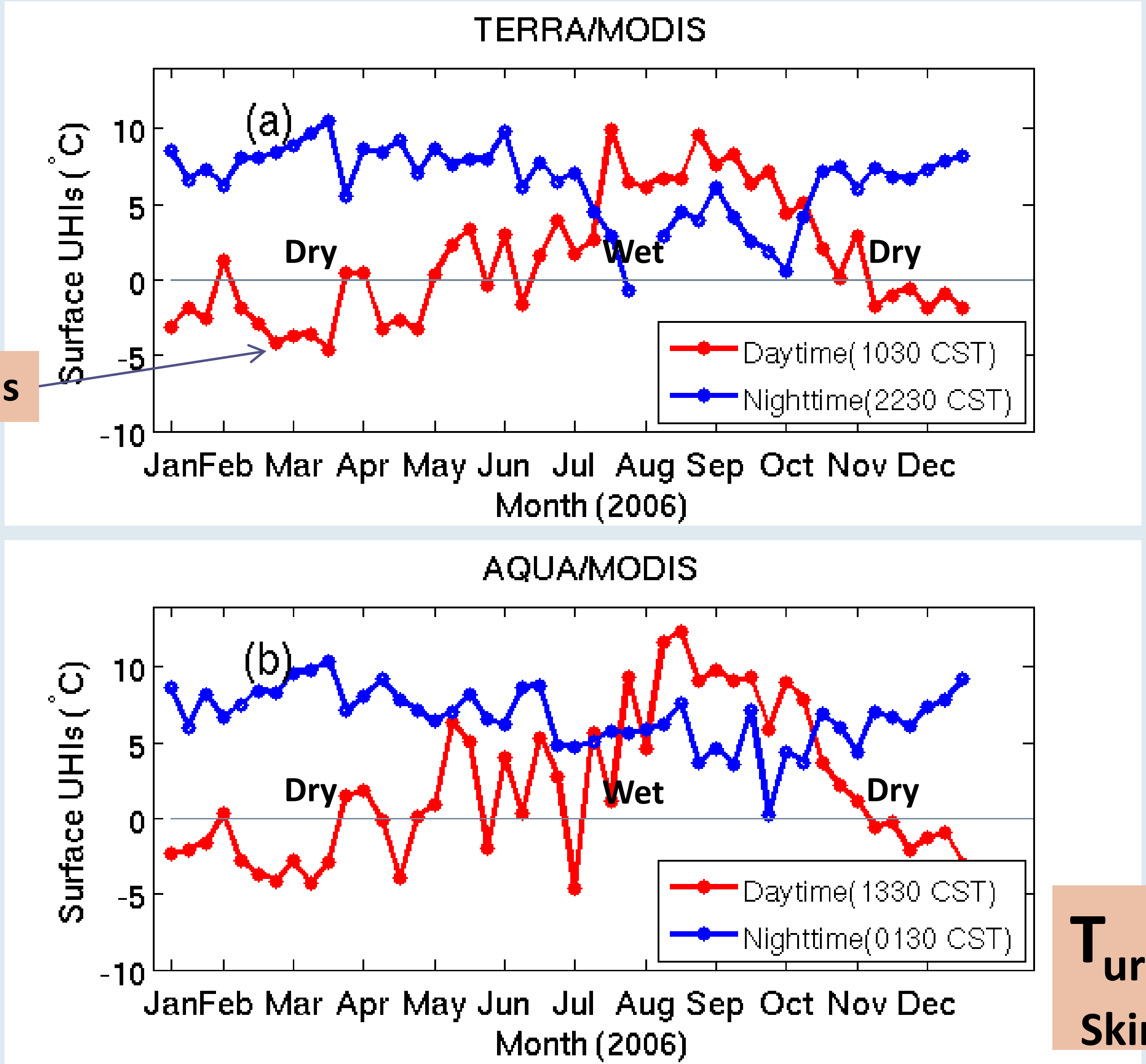
Canopy Layer Urban Heat Islands and Two data sources

Two research domains to derive the intensity of the surface heat island

Two surface sites (TEZO and MONT) with same elevation
→Explore the behaviors of the surface and near-surface heat islands.



Temporal seasonal variations of surface heat islands obtained from MODIS



Cool Islands

2006-2010

T_{urban}-T_{rural}

Skin of Earth

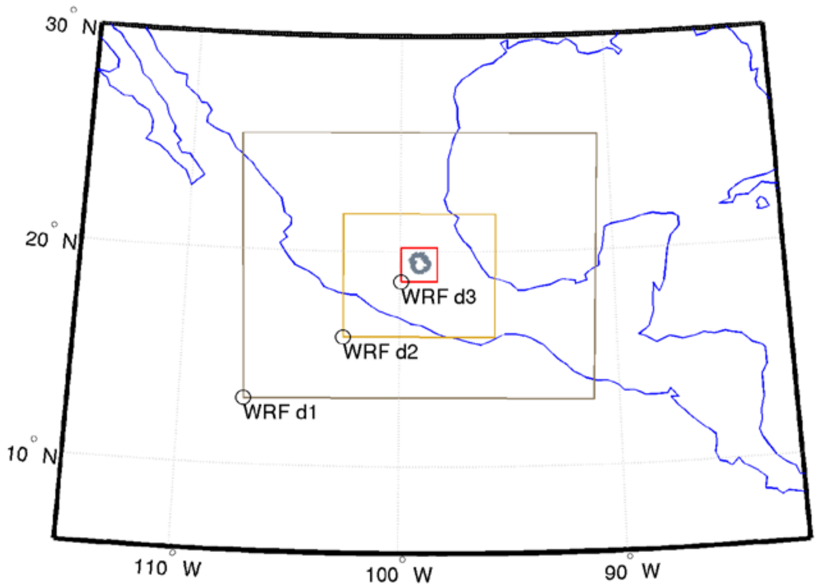
WRF Configuration

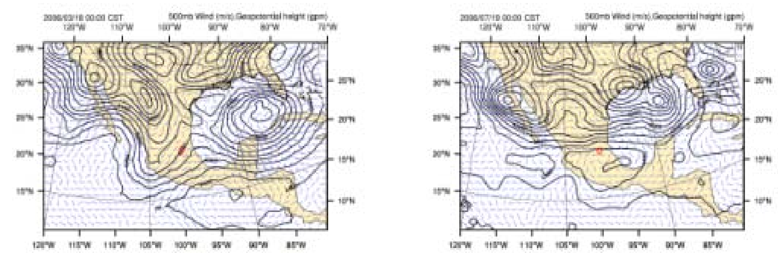
-ARW-WRF v3.2.1 with 3 nested domains and one-way nesting:
27km, 9km, 3km

-GFS data

-***Baseline Physics in MCMA** (de foy et al. 2009 ACP)*
YSU PBL
Kain-Fritsch for cumulus
WSM6 for microphysics
Noah LSM (GFS and WRF)
RRTM LW; Goddard SW

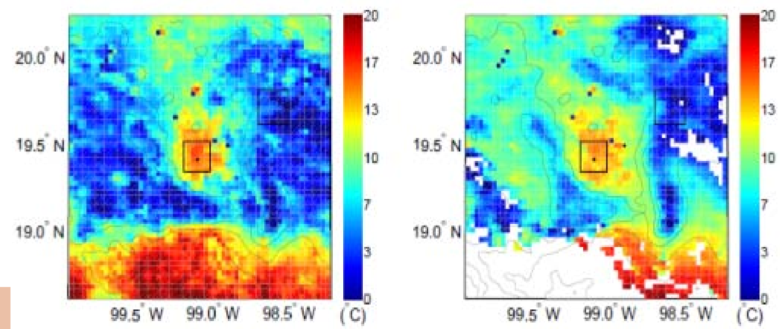
-***Episodes:***
14-20 March ; 14-20 July; 25-31 August;
14-20 October; 14-20 December
(42-hr spin up)





(a) 0000CST 18 March 2006

(b) 0000CST 19 July 2006



(c) 0130CST 18 March 2006

(d) 0130CST 19 July 2006

Clear Sky

Latent heat in Noah

1. ***Remove the hard-coded change in Noah for urban grid cells***
(the soil moisture of the dry point , the wilting point)→ restore the normal soil properties for urban cells.   E.g. Phoenix city.

2***. Change some parameters for urban/building-up category:***

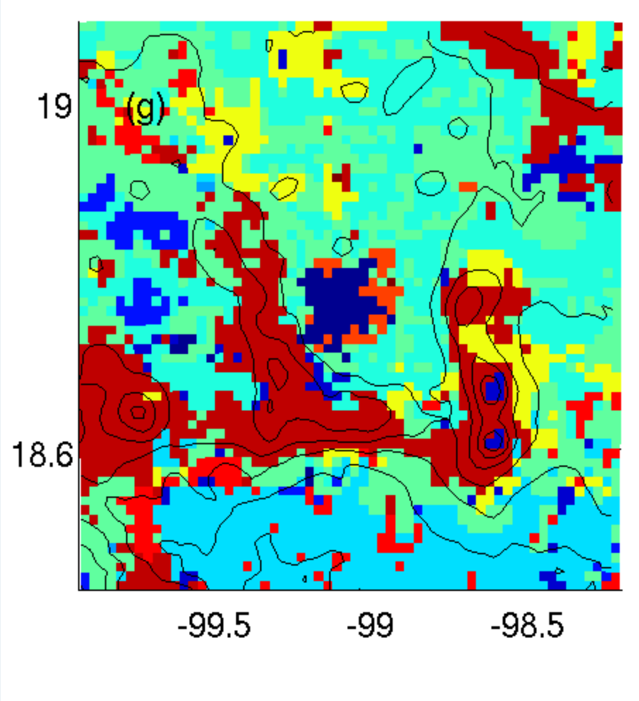
Parameter	value
Root depth	1→ 3 layers
Radiation stress function parameter	100
Vapor pressure deficit function parameter	40
Surface roughness length	80→ 25 cm

Summer values for the land use properties

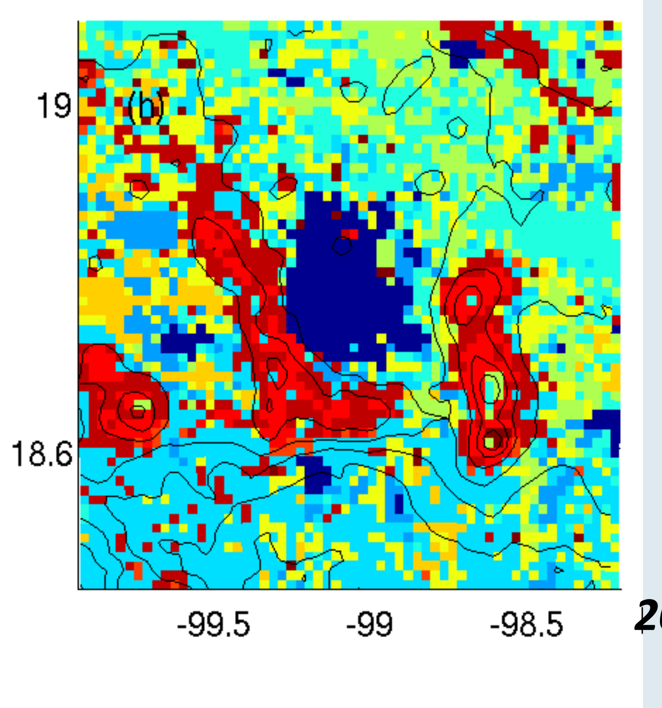
MODIS land products initialize the land surface in WRF

- ***Land-use index:*** MODIS/Terra Land Cover Type 1 (IGBP) yearly L3 1-km (MOD12Q1) ; lake cells

Base Case



Modified Case

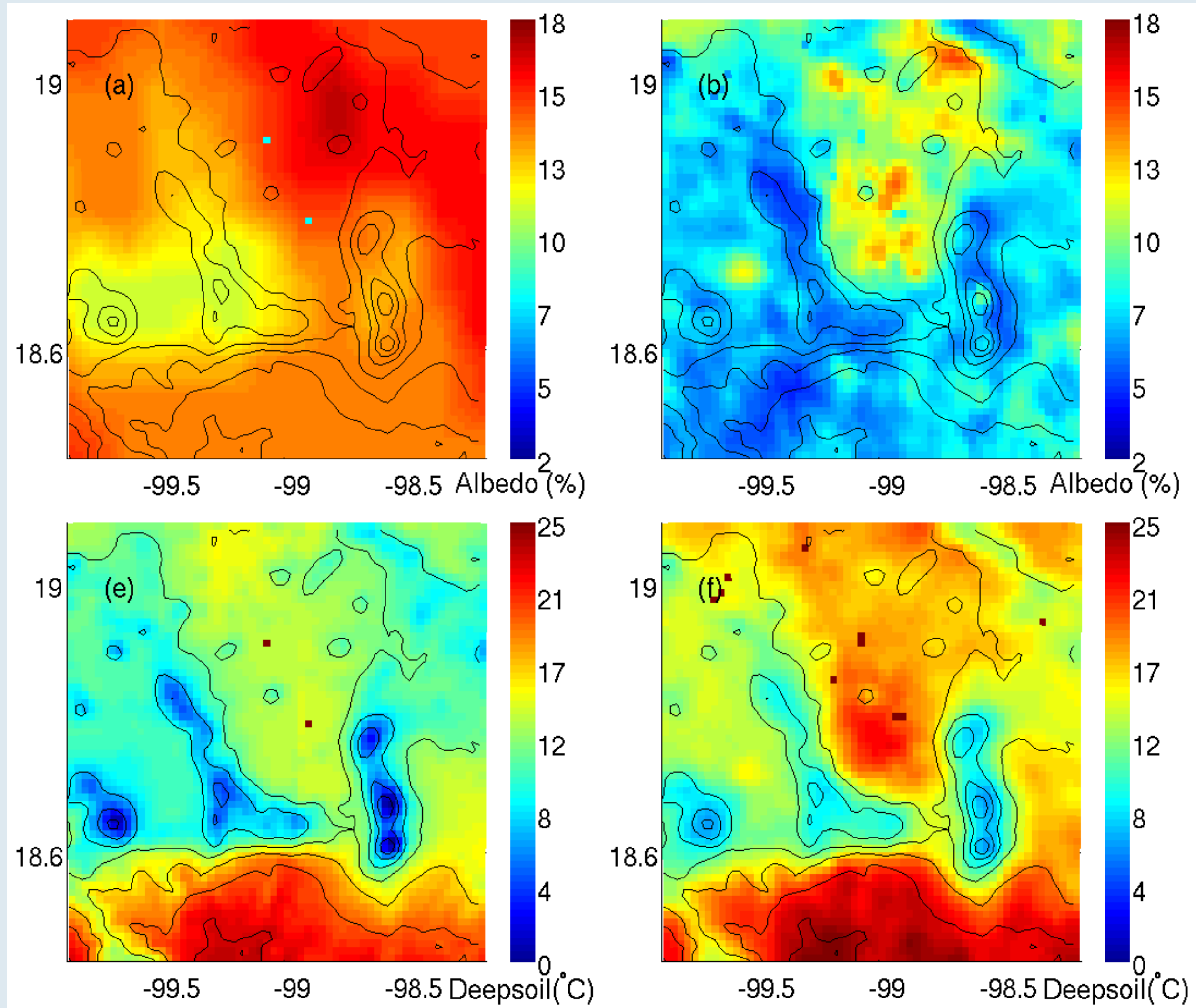


2004

WRF already did !

- ***E.g. July episode***
- ***Surface albedo:*** MODIS/(Terra+Aqua) Albedo 16-day L3 1-km (MCD43B3)
- ***Soil temperature:*** Terra/MODIS and Aqua/MODIS LST/E 8-day L3 1-km (MOD11A2 and MYD11A2)

Base Case ***Modified Case***

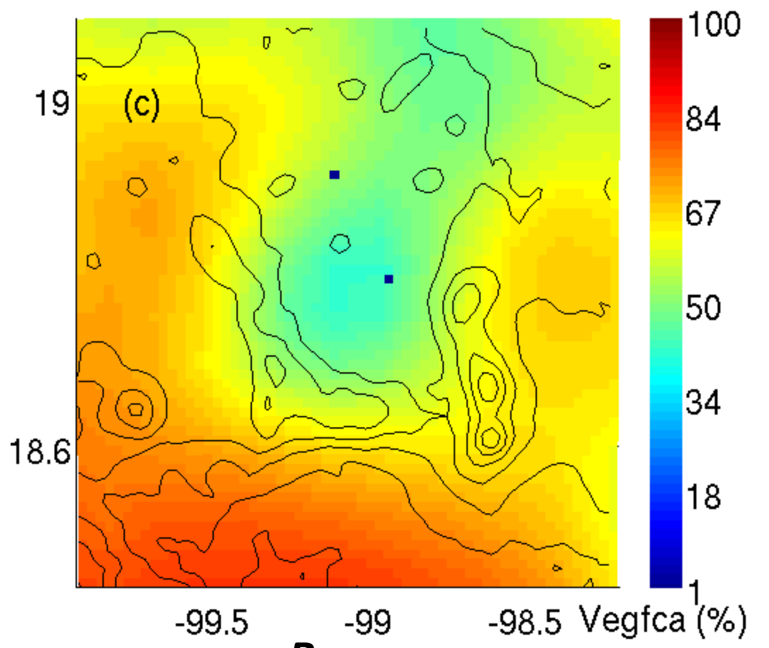


de Foy et al. 2006b ACP

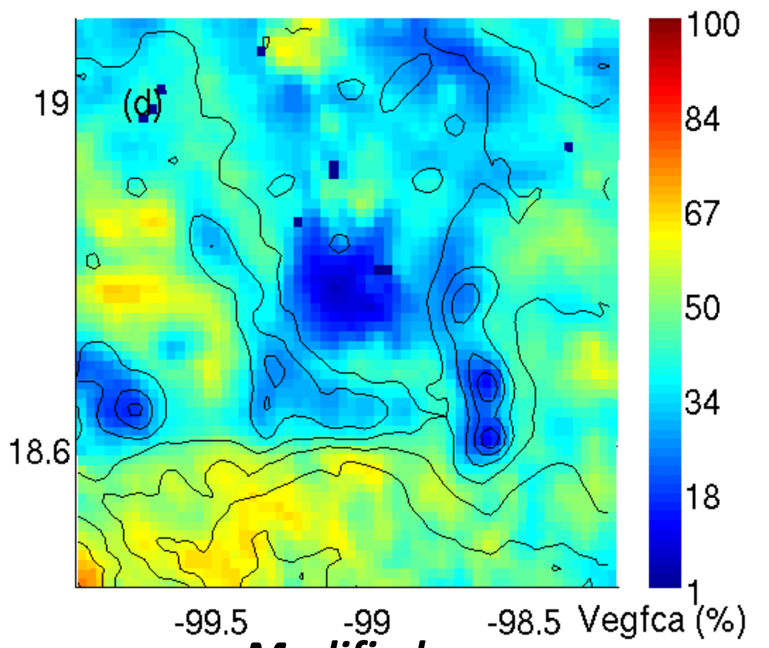
- ***Vegetation fraction:*** Terra/MODIS 8-day reflectance data (500m) (MOD09A1)

$$f_{veg} = \frac{(\mathrm{N} - \mathrm{R}) - (\mathrm{Ns} - \mathrm{Rs})}{(\mathrm{Nv} - \mathrm{Rv}) - (\mathrm{Ns} - \mathrm{Rs})}$$

(Jiang et al. 2006)



Base case



Modified case

Singer-layer UCM

- $$Q_{GRID} = Q_{UCM} \times f_{urb} + Q_{NOAH} \times (1 - f_{urb})$$

(Loridan et al. 2010; Chen et al. 2011)

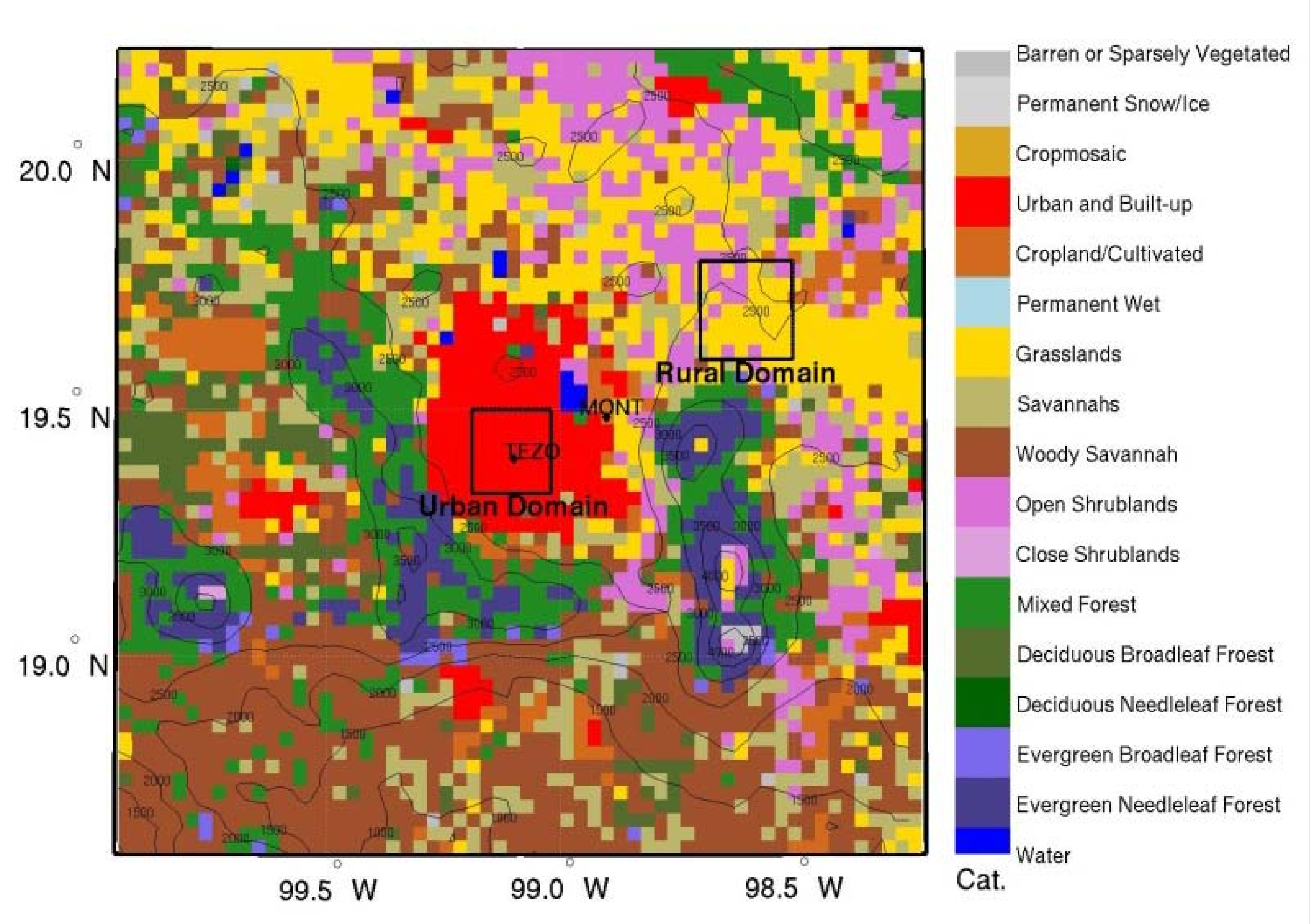
- MODIS → f_{veg} → $f_{urb} \backsimeq 0.8$
- High-resident category (default f_{urb}=0.9)

TABLE 1. Model test cases.

Case	*LSM*	*UCM*
Base run	NOAH	none
WRF-no-UCM	NOAH_modified	none
WRF-UCM	NOAH_modified	SL-UCM
WRF-UCM (80%)	NOAH_modified	SL-UCM (f_{urb}=0.8)

Dry season good, wet season too much diurnal variability

Two surface sites (TEZO and MONT) with same elevation →Explore the behaviors of the surface and near-surface heat islands.



Surface and Near-surface Heat Islands

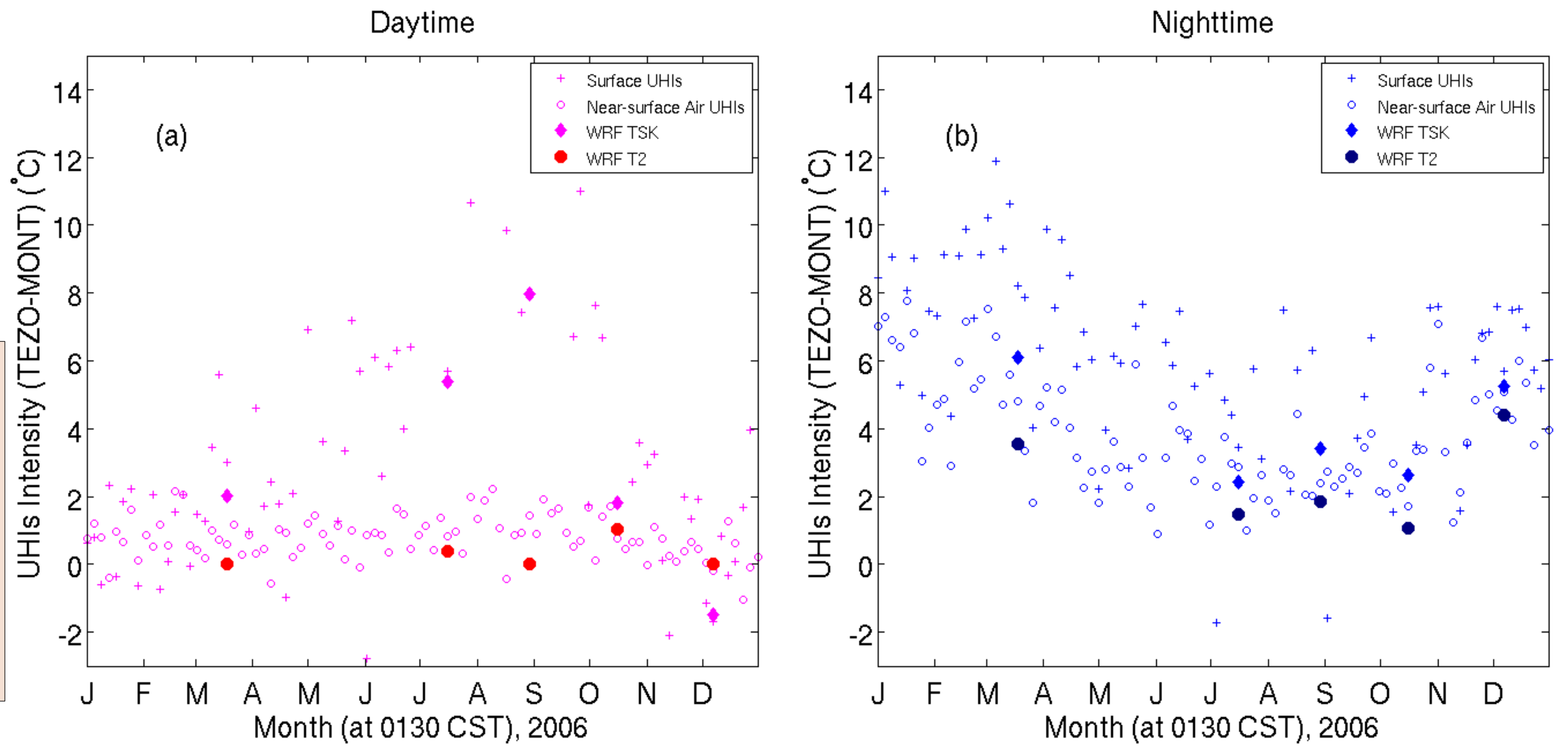
-Different Seasonal behaviors

-WRF simulate

TSK and T2

→ Reliably simulated the contrasting seasonal variations of two type heat islands

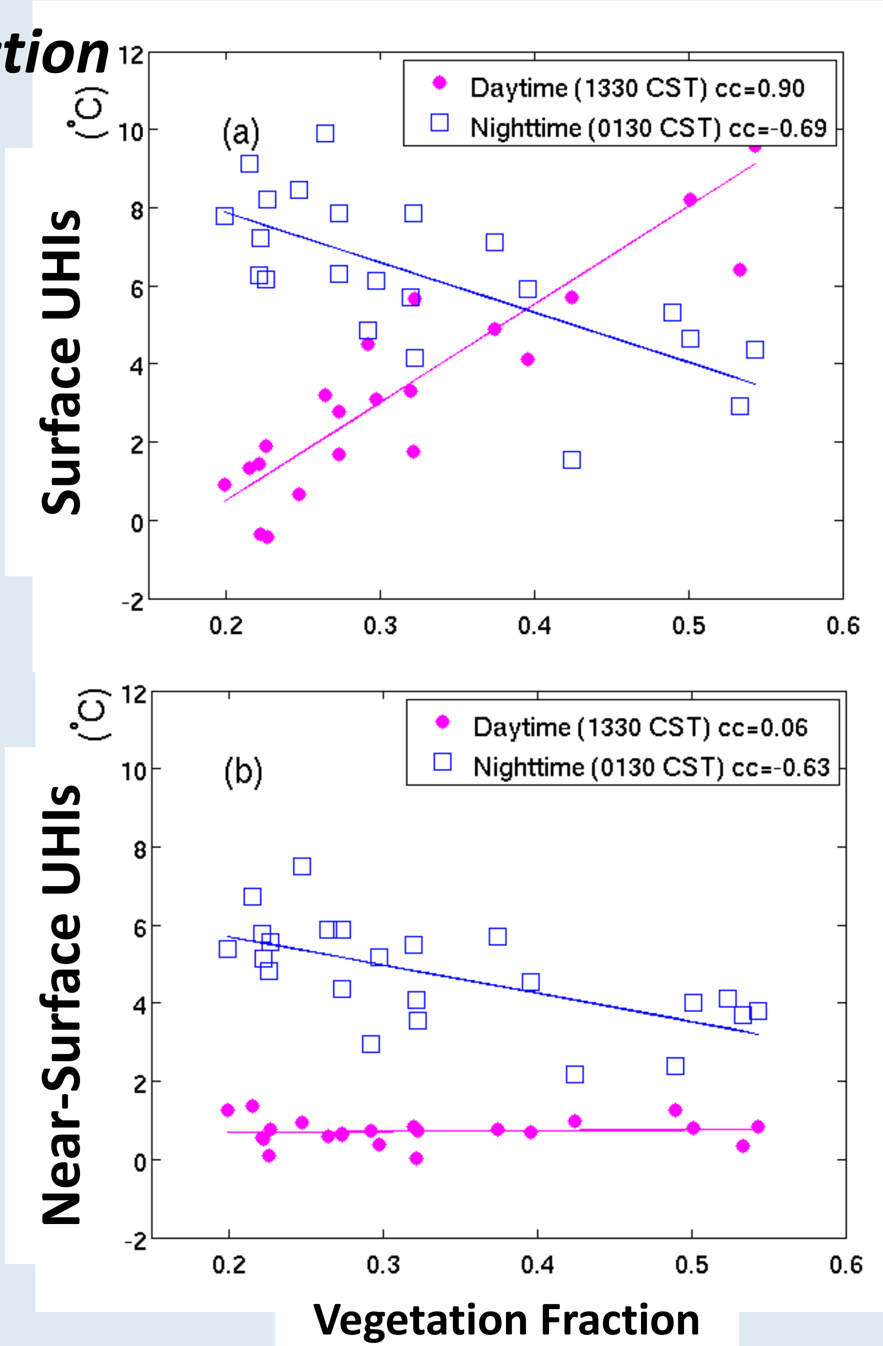
→ **Bridging role→ physical mechanisms**

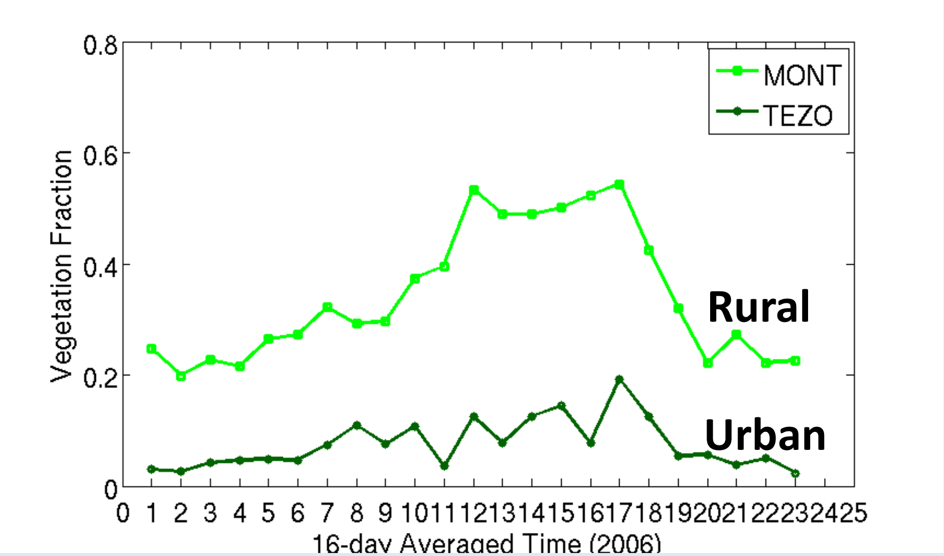


1.Remote Sensing
2.Surface Observations
3. WRF simulations

Seasonal variation of vegetation fraction

The seasonal variations of surface heat islands are highly correlated with the variation of vegetation. → need for green initiatives.





Summary

- **WRF plays a bridge role**
  -Explore the physical mechanisms and provide insight into Urban Heat Island behaviors.
- **Accurate representation of land surface in model**
  - More high resolution MODIS land products can be used, besides land-index.
- **In WRF modeling, latent heat for arid climates**
  -Increase the latent heat in the Mexico City to more realistic values, probably the case for most urban areas in arid climates.
- **The f_{urb} of UCM**
  -In the future should be ingested as a gridded field (MODIS).
- Questions?