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Simple urban parameterization for high resolution meteorology and air quality.

Jonathan Pleim, Robert Gilliam, James Kelly, Kirk Baker, and Chris Misenis, USEPA

Limei Ran, UNC

Office of Research and Development
Atmospheric Modeling and Analysis Division, National Exposure Research Laboratory

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A Simple Bulk Urban Approach for PX LSM

- Leverage very high resolution National Land Cover Database (NLCD) with multi-level urban classifications
  - PX LSM considers subgrid LU fractions
- Utilize NLCD-based Impervious surface data directly in land-surface model to scale surface heat capacity
- Increase surface roughness for urban LU classes to better represent developed areas
- Decrease albedo in urbanized areas to account for sky-view and radiation trapping effects
- Use NLCD tree canopy coverage data in ET model

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Effects of Urban Modifications

- Higher surface heat capacity of impervious surfaces:
  - Greater heat storage → warmer nighttime temperatures
  - Less stable nocturnal boundary layer
  - Less H in late morning greater H in afternoon/evening
  - Reduced overprediction of emitted concentrations in evening and early morning.
- Reduced albedo
  - Increases daytime heating but countered by greater HC
- Increased roughness → greater u_*, lower windspeed

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Model Evaluation

- Houston – TexAQS 2006
  - WRF 12/4/1 km with and without urban mods
  - CMAQ 4 km with and without Urban
- CARES/CALNEX 2010 – 4km WRF, CMAQ, WRF/CMAQ
  - Effects of urban treatment on surface T, H, PBL, NO_X, O_3
- DISCOVER-AQ 2011
  - WRF and WRF/CMAQ 12/4/1 km with and without Urban
  - Preliminary results

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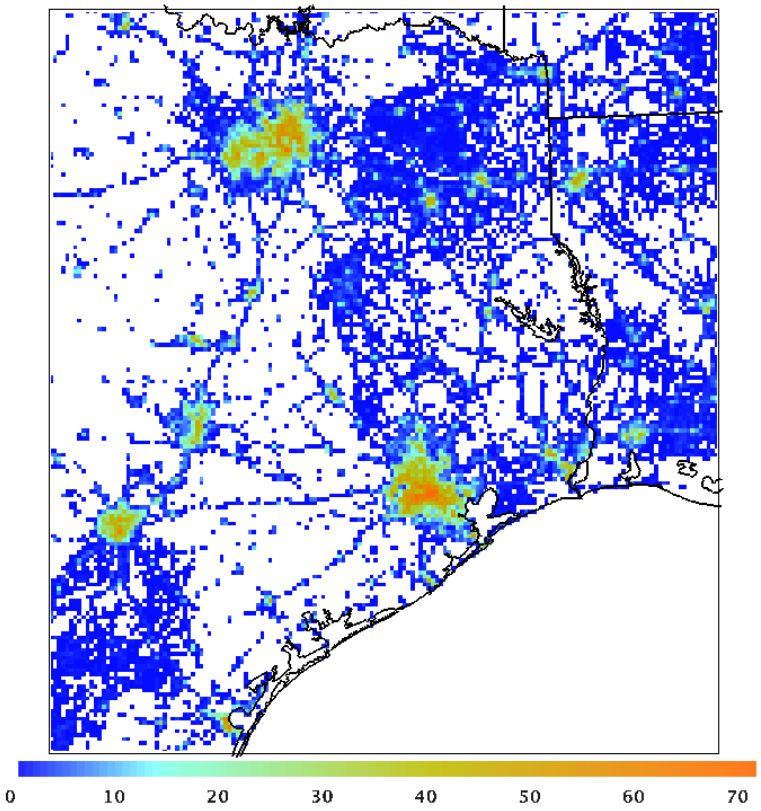
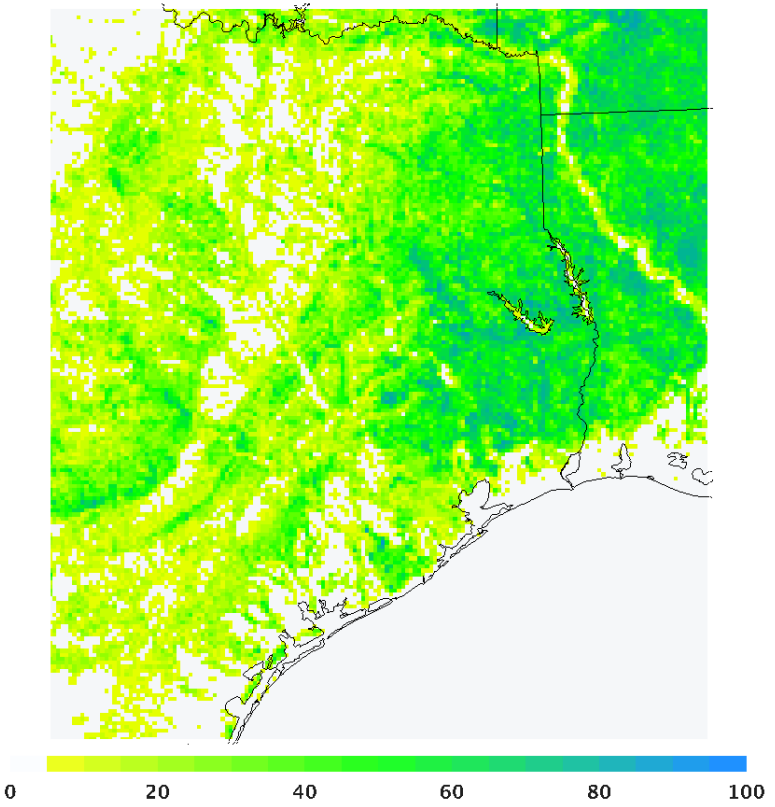
Impervious and Canopy Fraction (%) for 4km Grid



Impervious surface fraction (%)



Canopy fraction (%)

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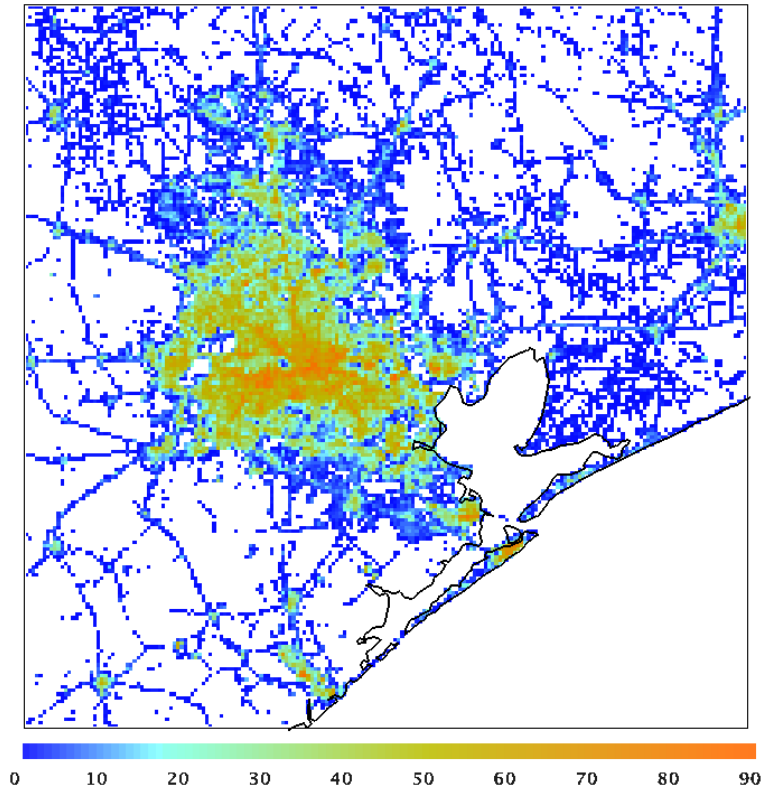
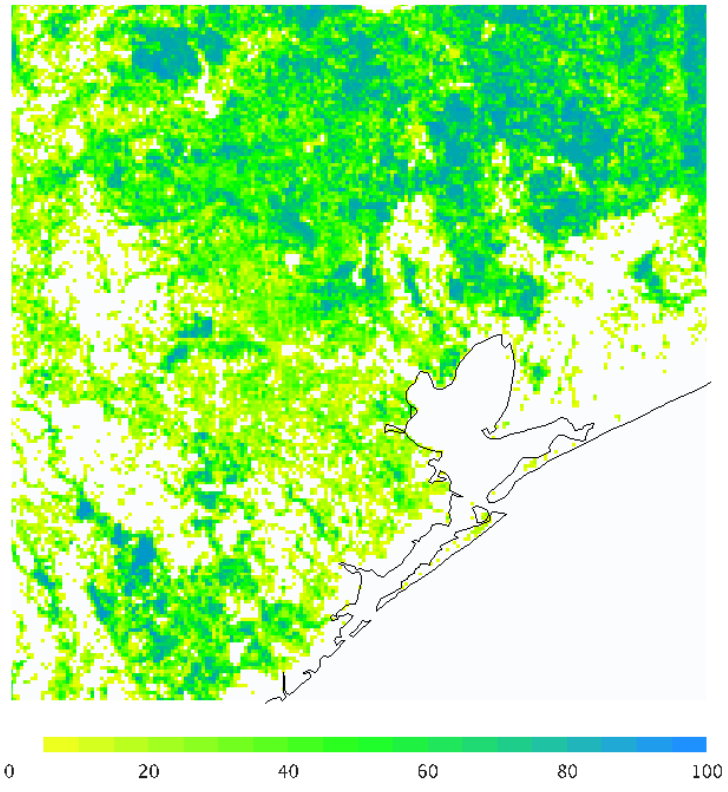
1 km Model Grid for Houston, TX



Impervious surface fraction (%)



Canopy fraction (%)

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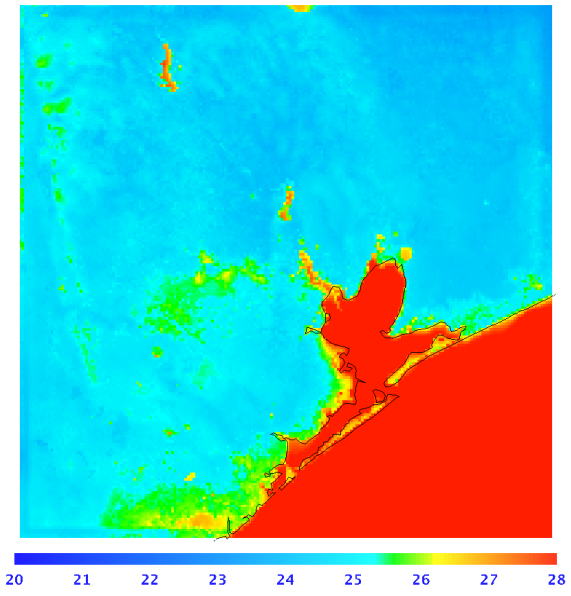
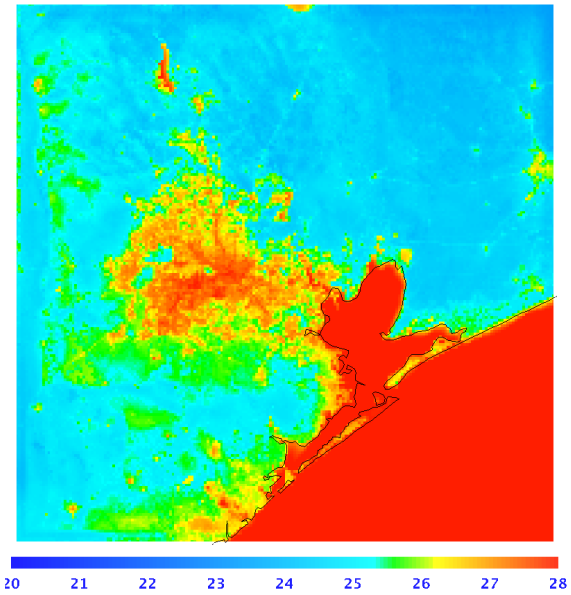
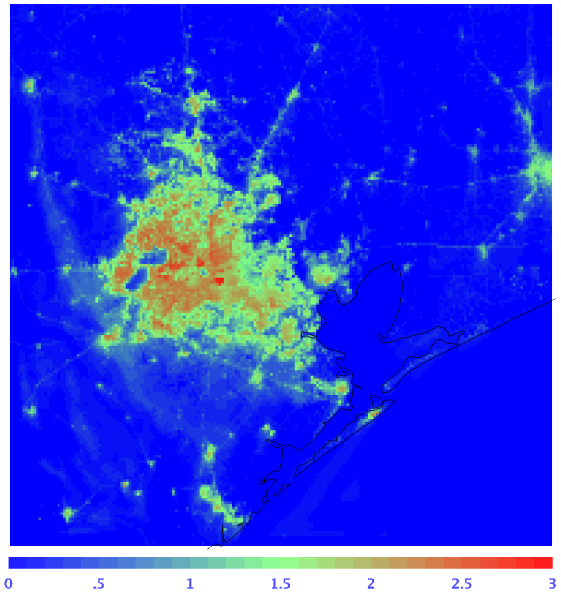
2-m Temperature at 6 AM LT, Aug 31, 2006



Base



Urban



Urban - Base

Urban model show early morning UHI while base model doesn't

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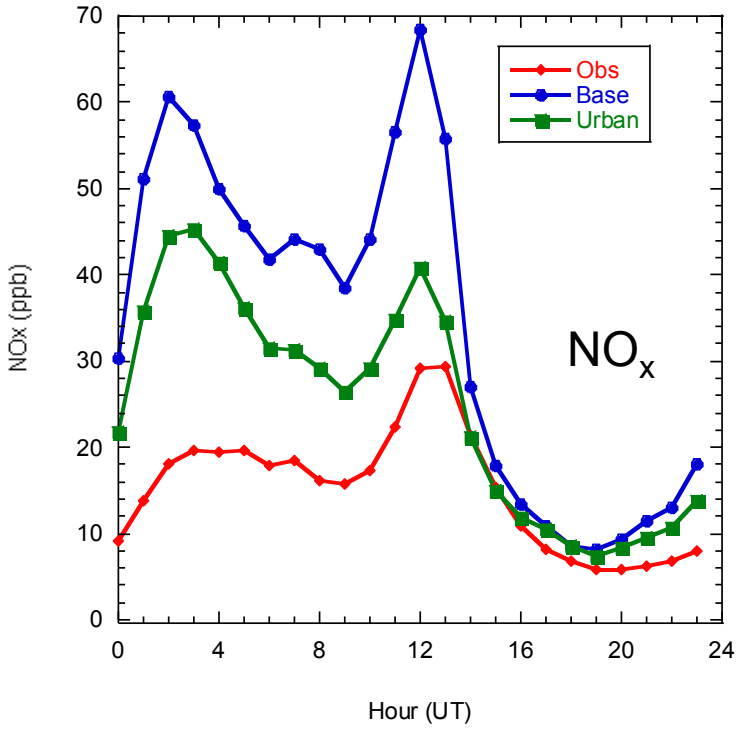
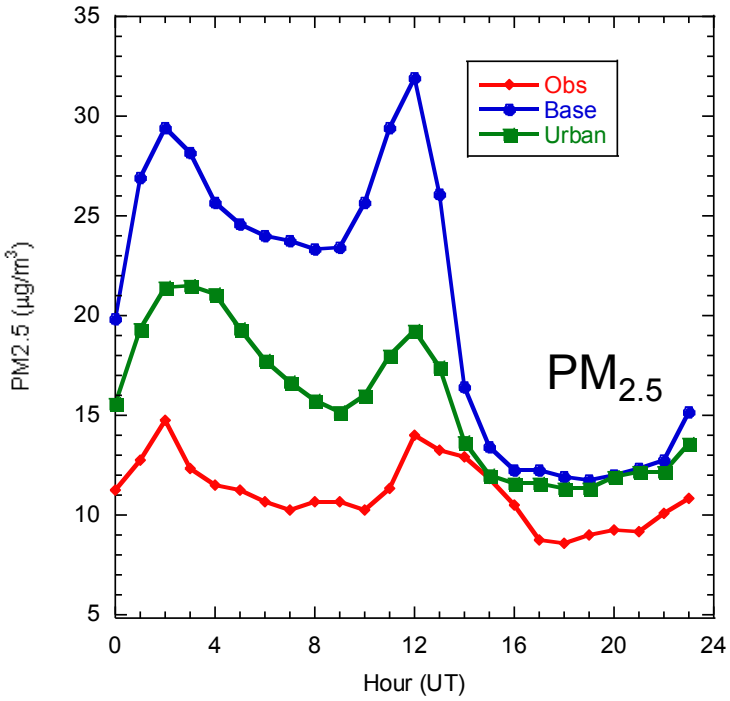
AQ in Dallas: August 24 – September 8, 2006



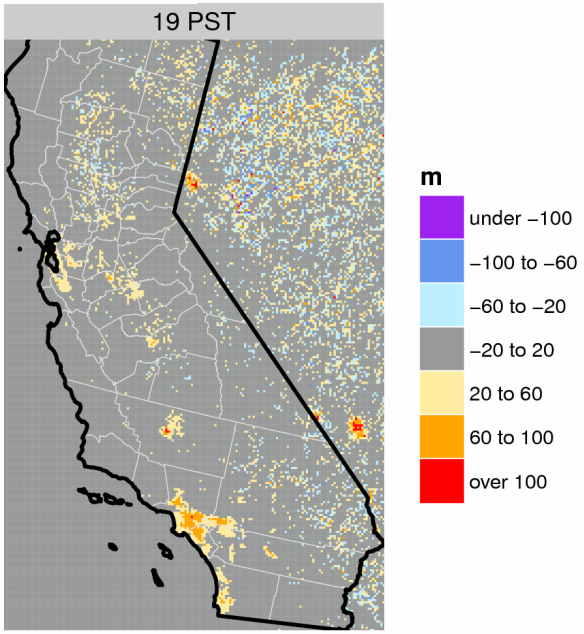


➢Urban mods effective for Dallas in lowering nocturnal NO_x and $PM_{2.5}$

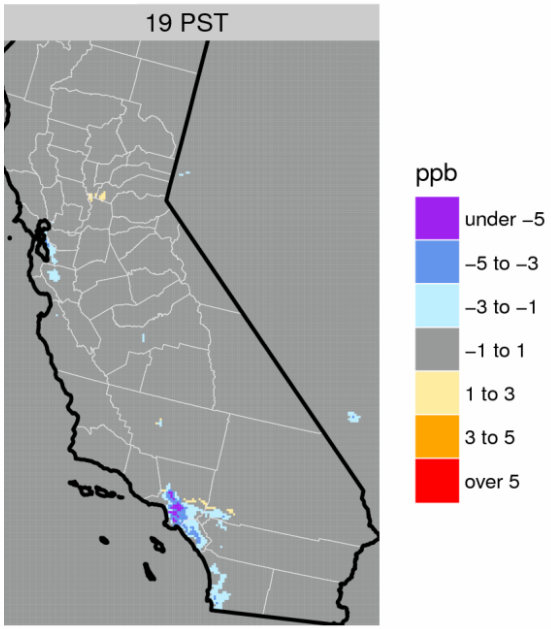
CALNEX /CARES May 7 – June 30, 2010

Average difference (Urban – Base) at 19 PST

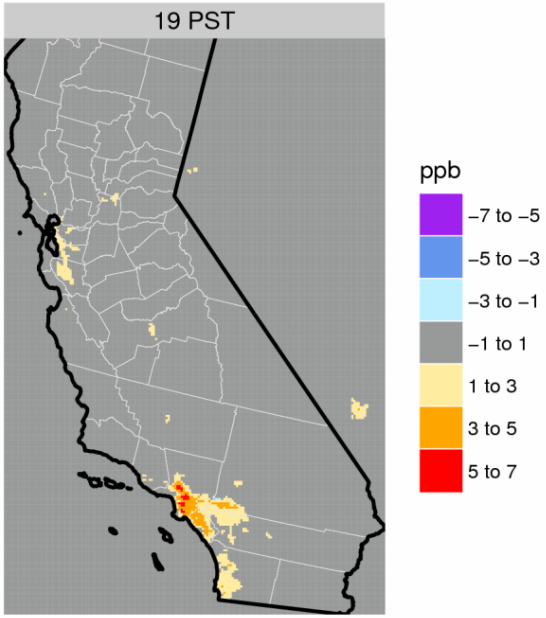
PBL ht



NO_x

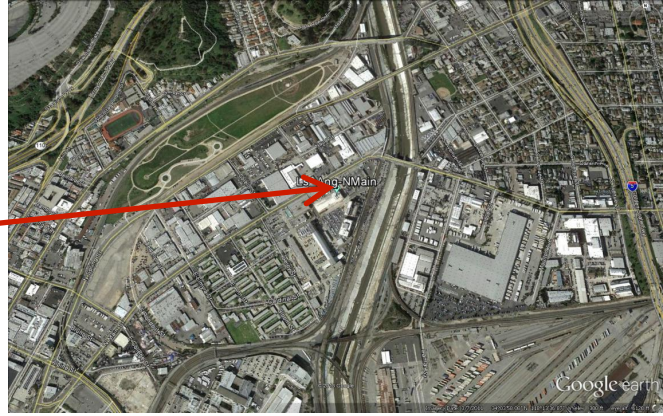


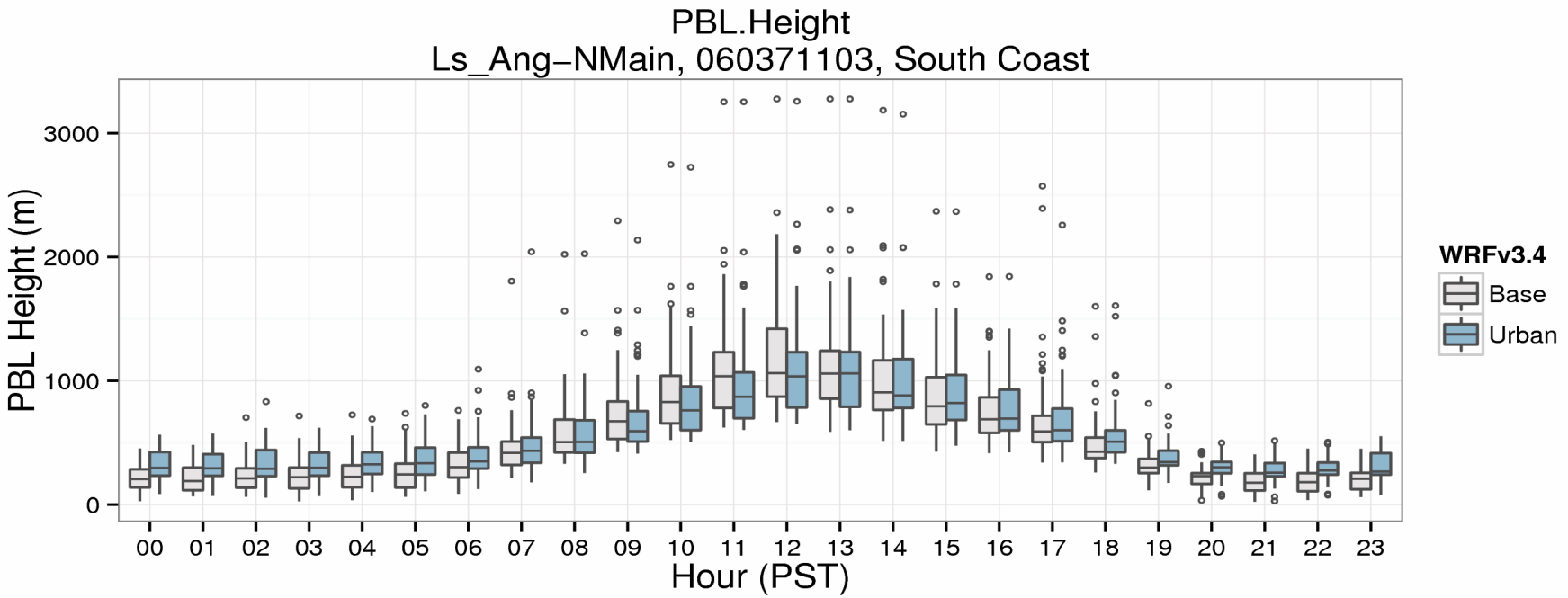
O_3



Slower evening collapse of PBL ht in urban areas reduces NO_x and increases O_3

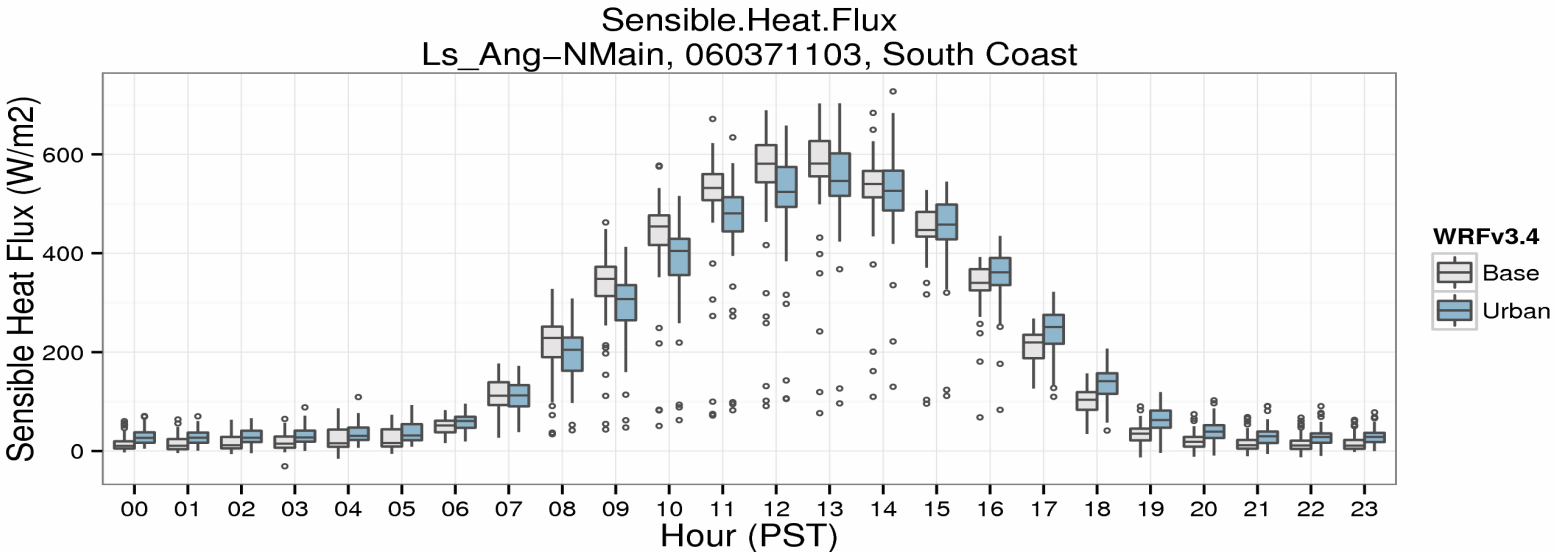
PBL Height
N Main St, LA
May 7 – June 30, 2010



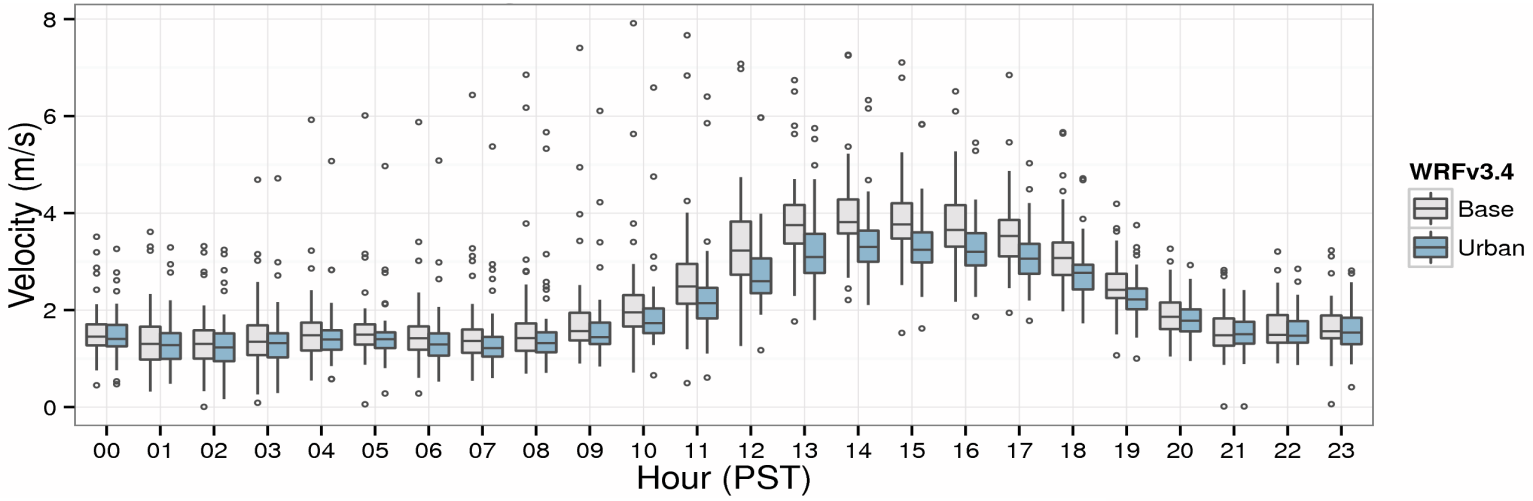


Urban scheme increases PBL ht at night and evening

N. Main St, LA

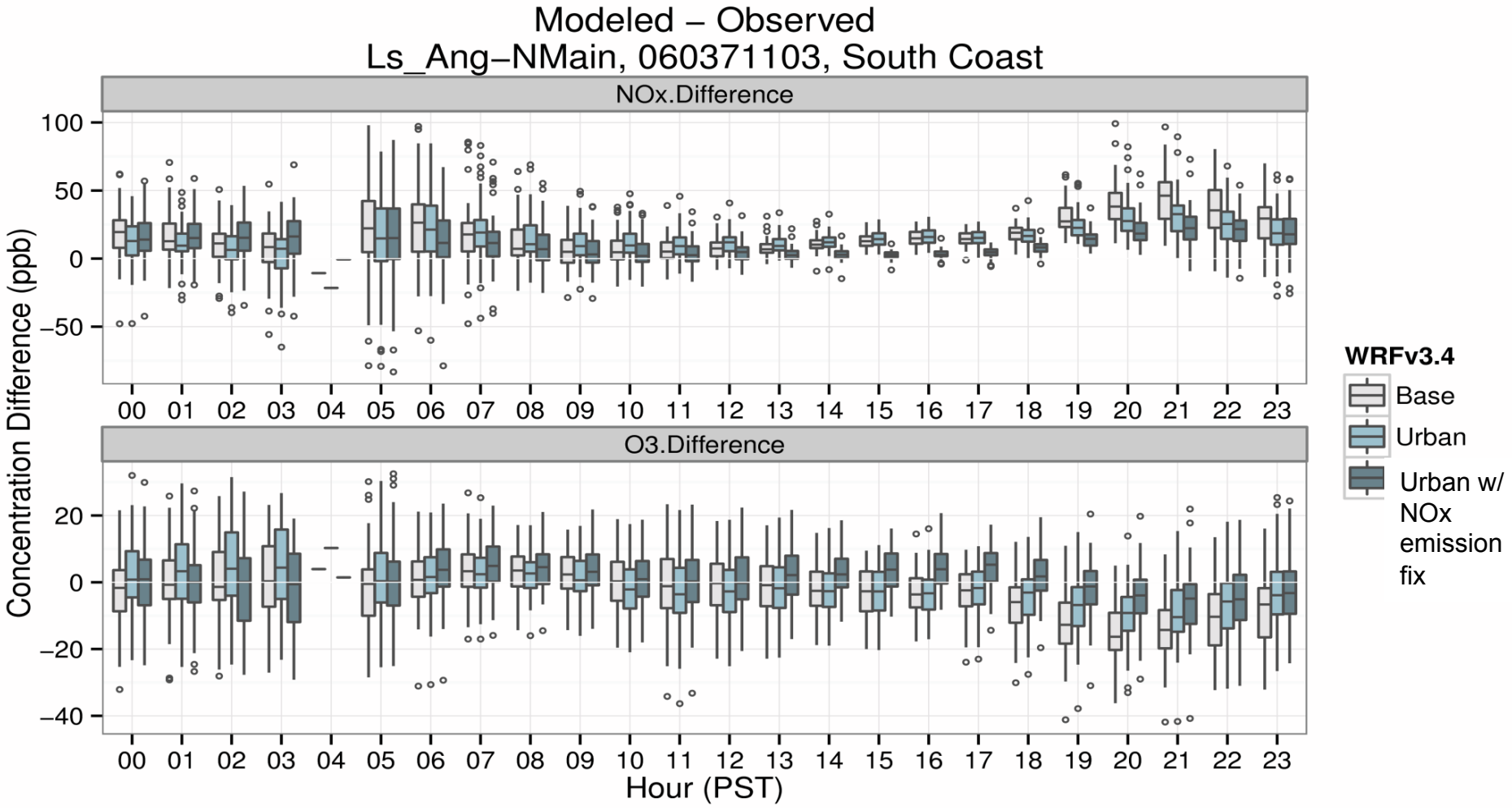


Greater HC decreases H in morning but increases in late afternoon and evening



Greater z_o in urban areas reduces wind speed

O_3, NO_x bias - N Main St, LA
May 7 – June 30, 2010



Urban reduces NO_x over- and O_3 under-prediction in evening and early morning

1 km WRF for Discover-AQ

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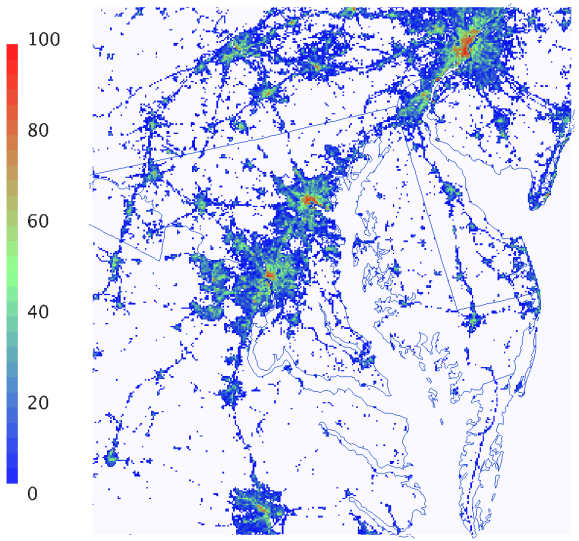
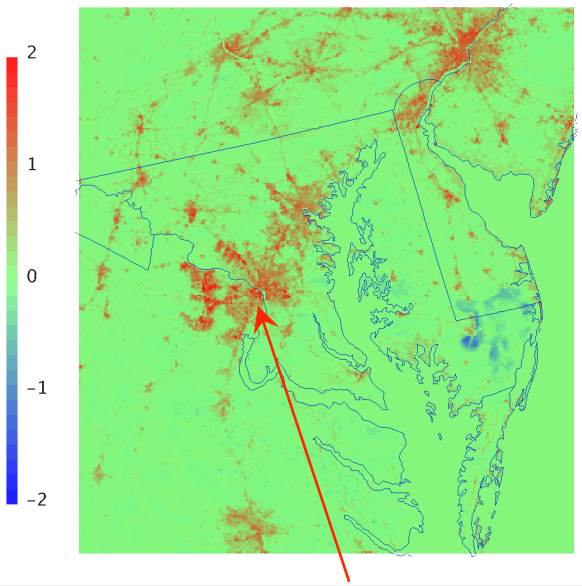
Urban - Base

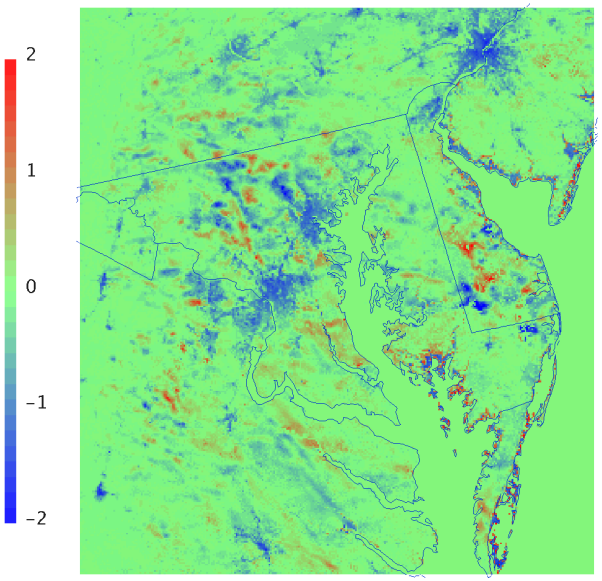
Impervious fraction

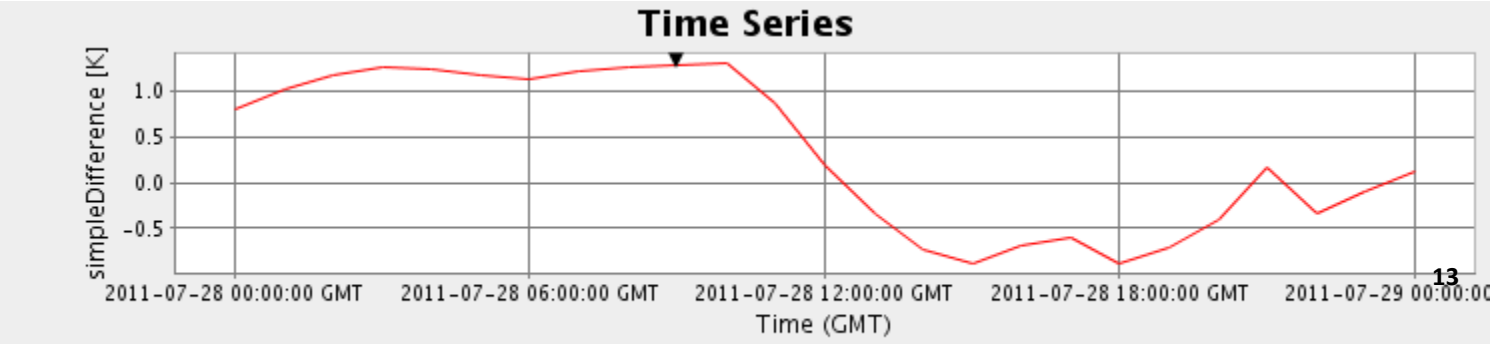


T_{skin} - July 28, 10Z



T_{skin} - July 28, 15Z





Scaling heat capacity by impervious surface results in warmer T_{skin} at night but cooler T_{skin} in morning

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Conclusions

- Simple urban parameterization using high resolution impervious fraction and canopy fraction improves surface energy and PBL simulation in urban areas
  - Better representation of nocturnal UHI effects
  - Slows stabilization during evening transition
  - Reduces nighttime, early morning, and evening overpredictions of ground emitted pollutants

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Next steps

- Add simple algorithm for anthropogenic heating and moistening, leveraging data in emission inventory database such as population density, FEMA building square footage, and mobile emissions
- Comprehensive evaluation of 2-way coupled WRF/CMAQ model simulation with urban scheme at 4 km and 1 km grid resolution using field measurements from DISCOVER-AQ 2011