

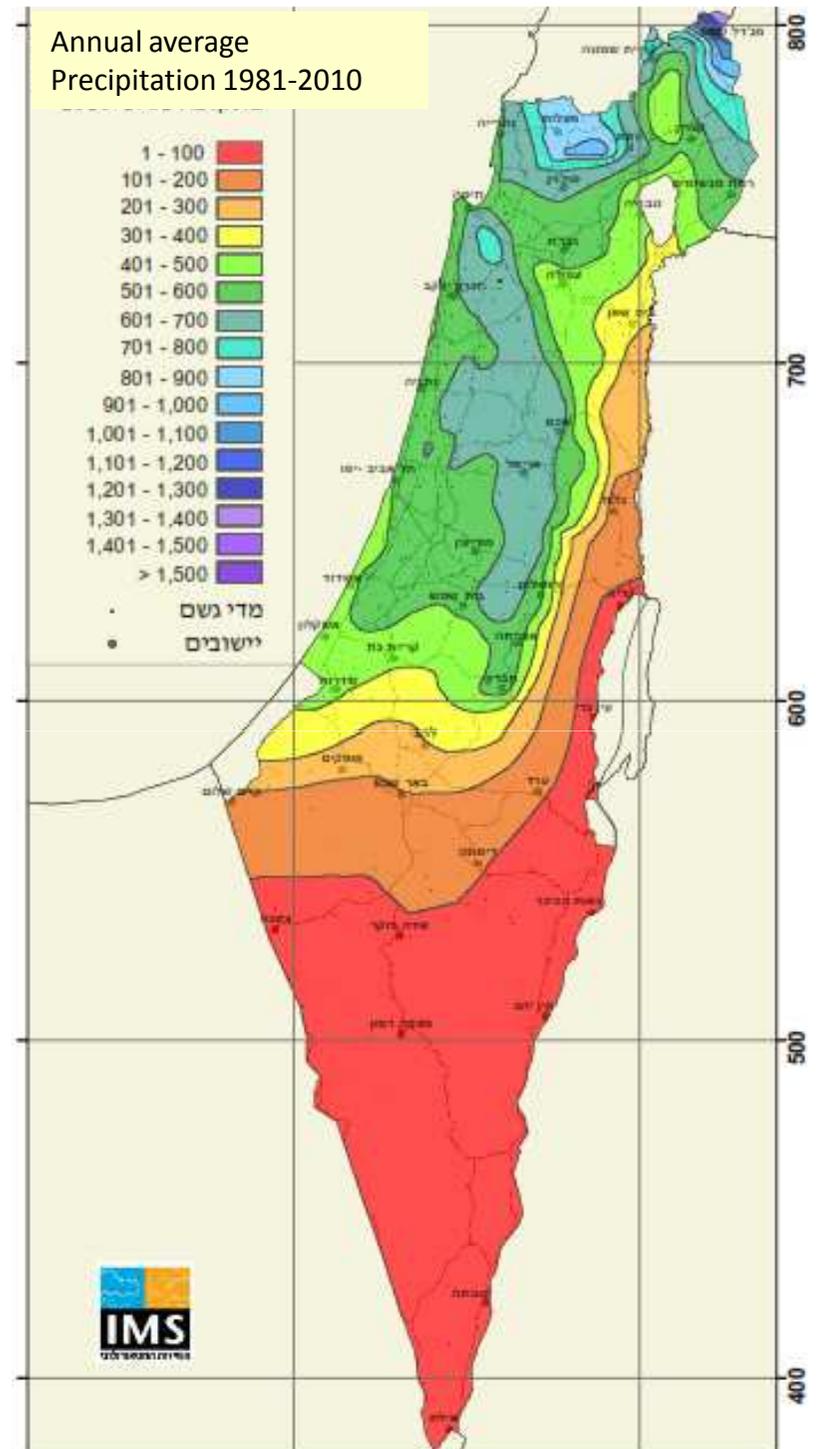
# ***Impact of future urbanization on a hot summer: A case study of Israel***

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# Israel

- Area = 22,000 km<sup>2</sup>
- Climate: Hyper-Arid to dry sub-tropical with strong temperature and precipitation gradient: N-S & E-W.
- Climate change projections:  
Temp.  $\uparrow$  0.4-0.8°C / P $\downarrow$  ~15%



# The Urban landscape

- Cities existed since biblical time...
- Modern urban landscape (Impervious surfaces) – mostly post 1948

## Tel - Aviv



Late 1950s



2010

# Population growth

- Growth rate = 1.9%
- 91% live in urban areas.

Future projection (thousands)

	UN			Israel Central Bureau of Statistics		
Year	Low	Medium	High	Low	Medium	High
2020	8,666	8,687	8,846	8564	8843	9128
2035	10,386	10,690	11,043	9943	10981	12059
2060	12,961	14,765	15,218	11614	15608	20386



**Urban expansion/intensification  
of human activity**

# Objective

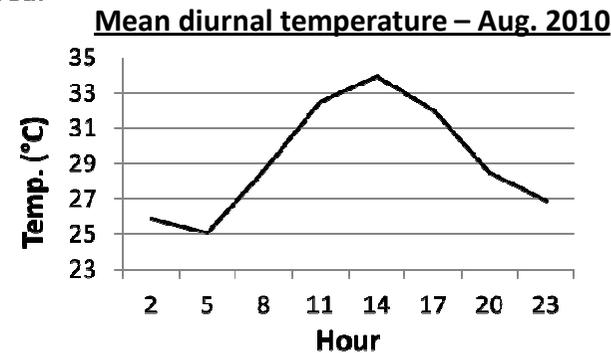
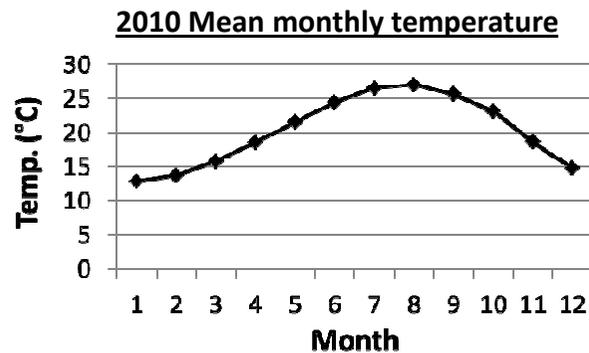
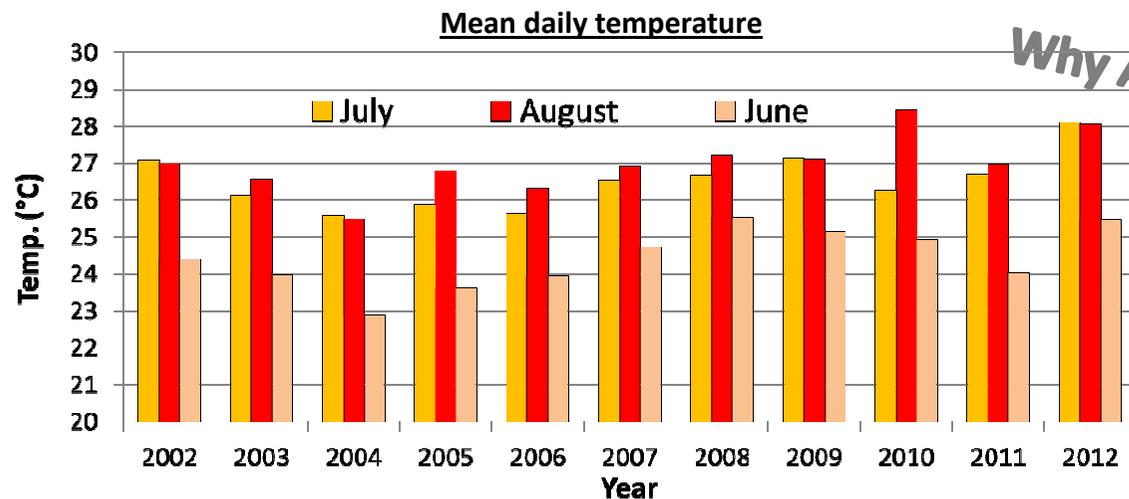
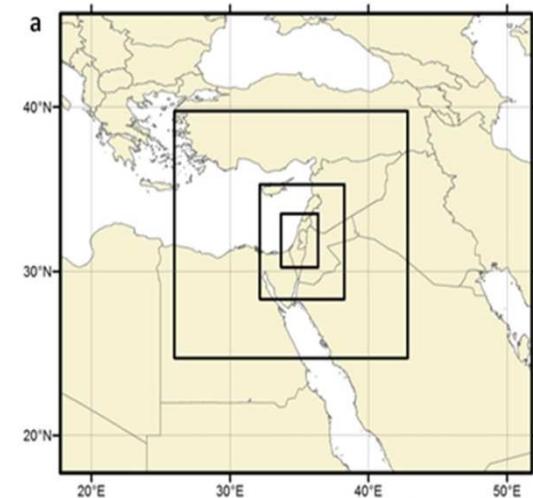
- Evaluate the potential first-order impact of future urban expansion on the summertime climate of Israel

## Research questions:

1. How will future urbanization impact summer climate?
2. Compare and contrast impact of future urbanization along a climatic gradient

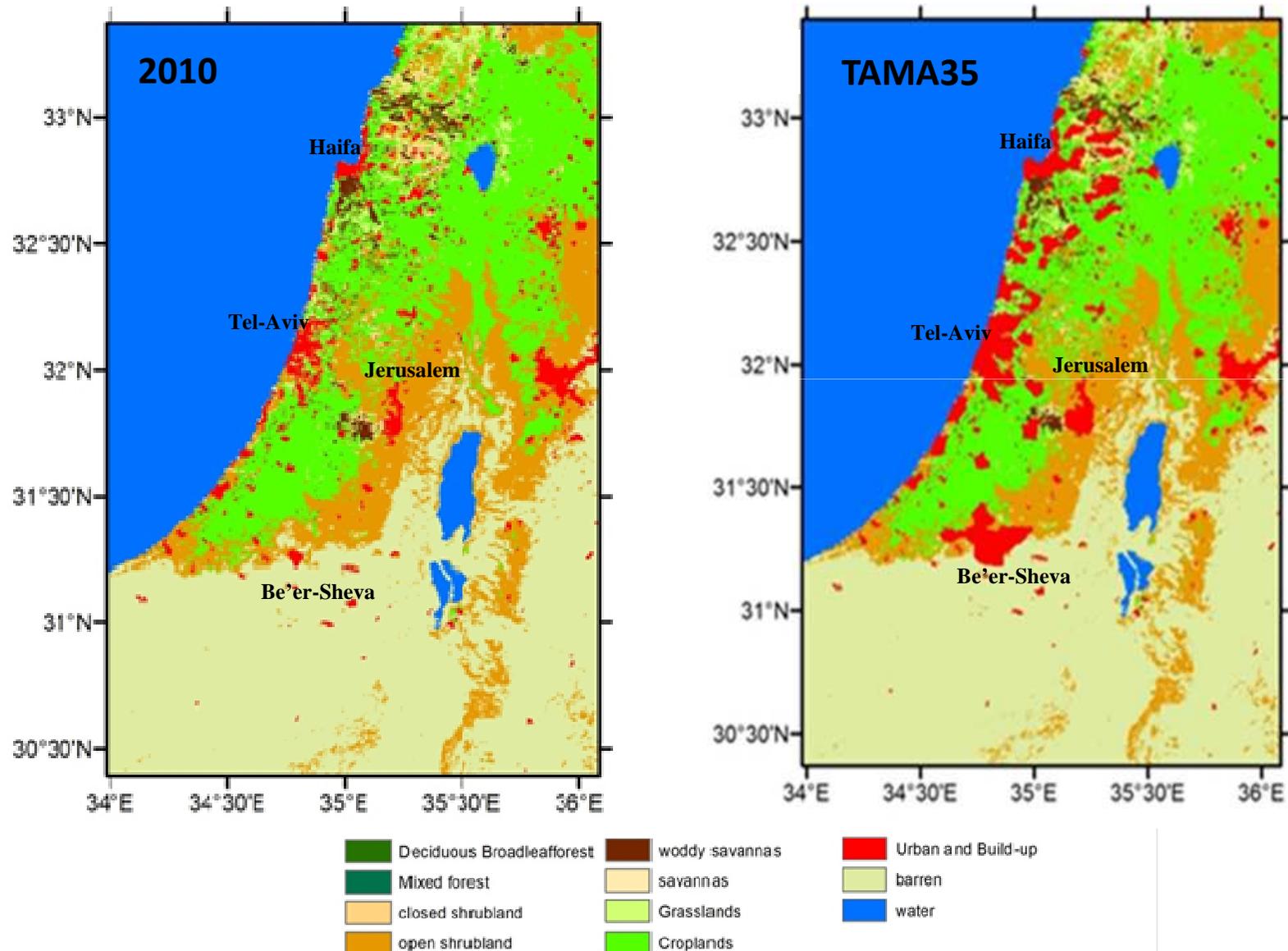
# Methods

- WRF V3.4.1
- Single-Layer Urban Canopy Model
- One way nested grids
- Spatial resolution: 1 km resolution
- Paired simulations: Aug. 2010 vs. TAMA35 (National development plan)



# Urban expansion scenario

- MODIS-based land use classification
- Urban grid cells => High intensity residential

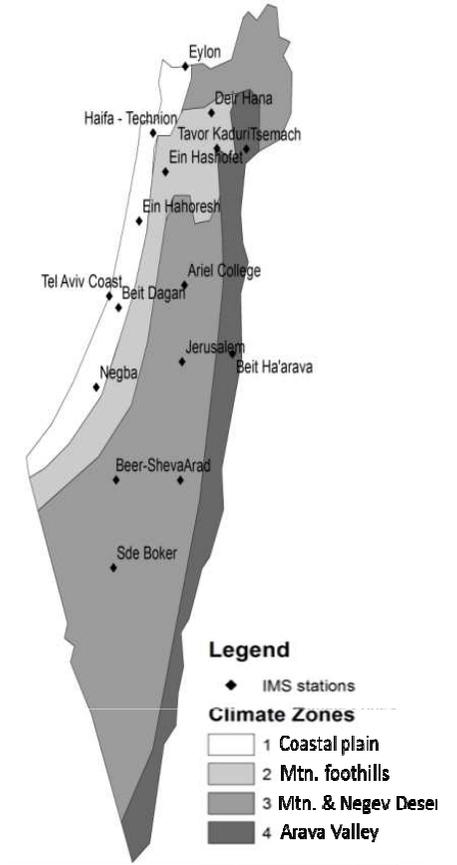
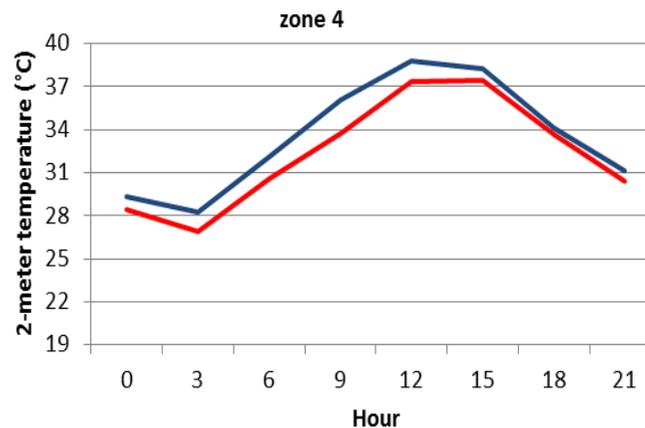
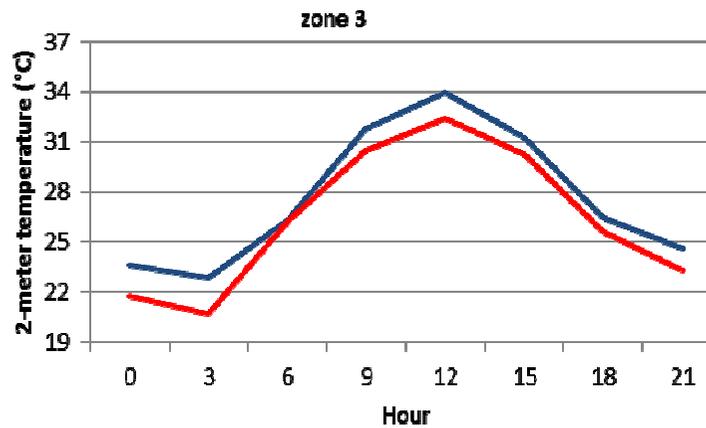
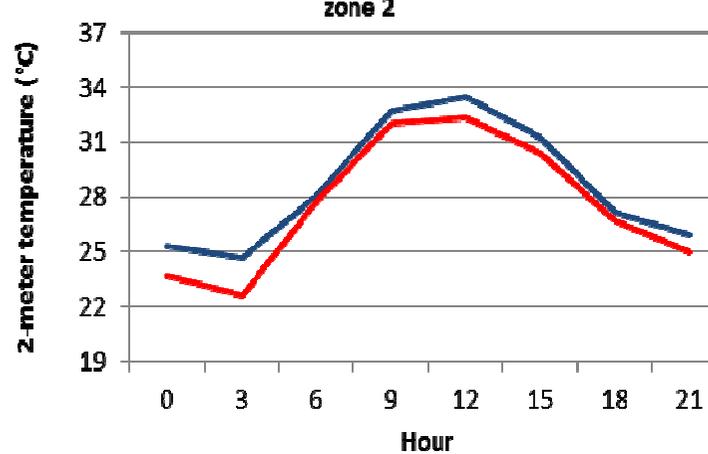
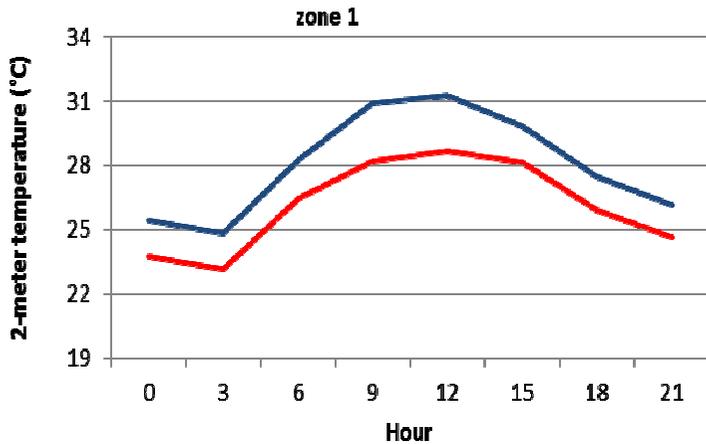
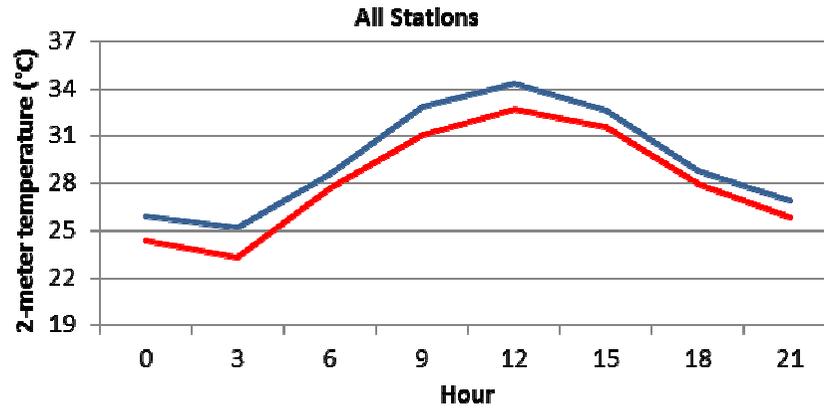


# Results: Model evaluation

$R^2=0.86$

RMSE=1.27°C

Cold bias



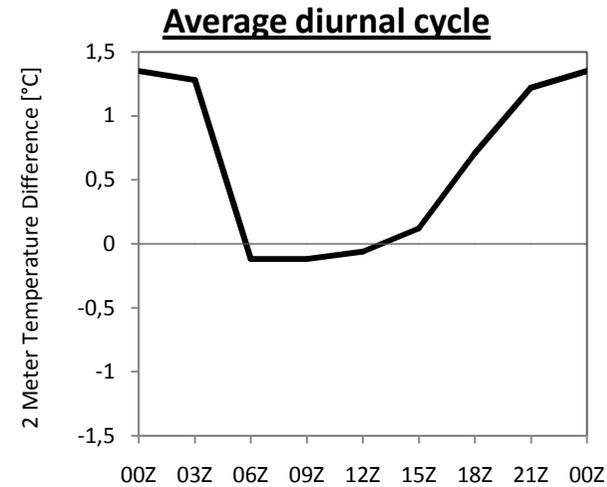
Climate zones classification for summer [Erell et al., 2003]

# Effect of LULCC on simulated temperature

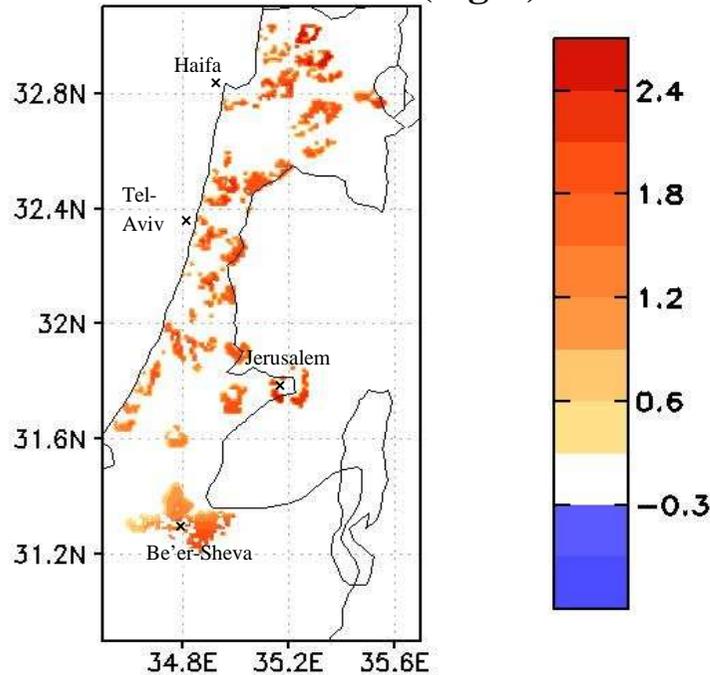
$\overline{\Delta T}_{\text{all times}} = 0.4\text{-}0.8^\circ\text{C}$

$\text{Max}(\overline{\Delta T})_{\text{night\_all}} = 1.35^\circ\text{C}$

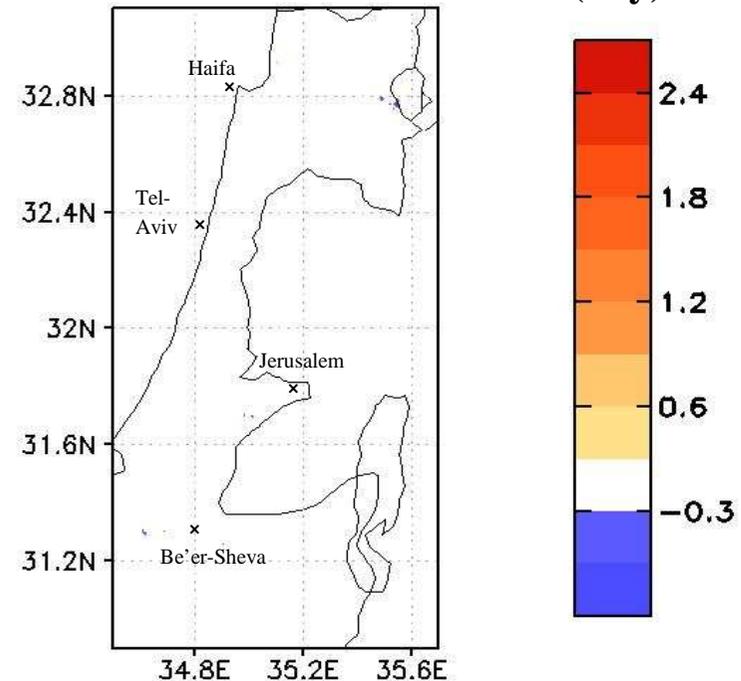
- $\text{Max}(\Delta T)_{\text{night\_north}} = 3.5^\circ\text{C}$
- $\text{Max}(\Delta T)_{\text{night\_TA\_}} = 2.3^\circ\text{C}$
- $\text{Max}(\Delta T)_{\text{night\_Jerusalem}} = 3^\circ\text{C}$
- $\text{Max}(\Delta T)_{\text{night\_BS}} = 2.1^\circ\text{C}$



**UrbanTAMA35 – Control (night)**

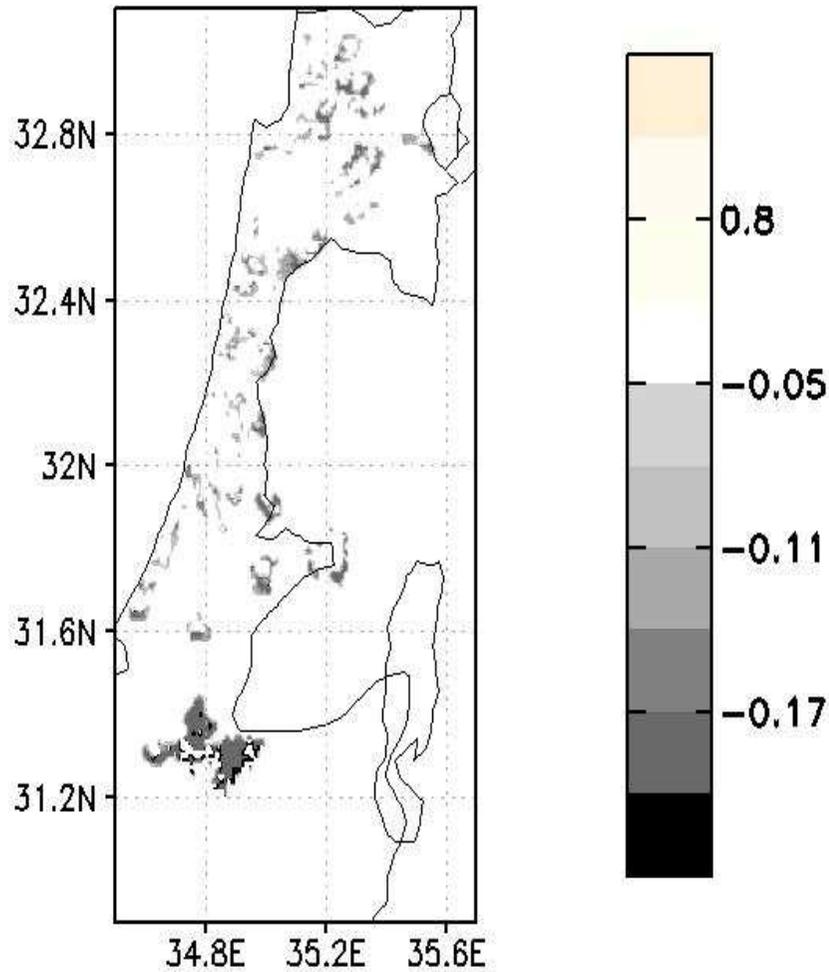


**UrbanTAMA35 – Control (day)**

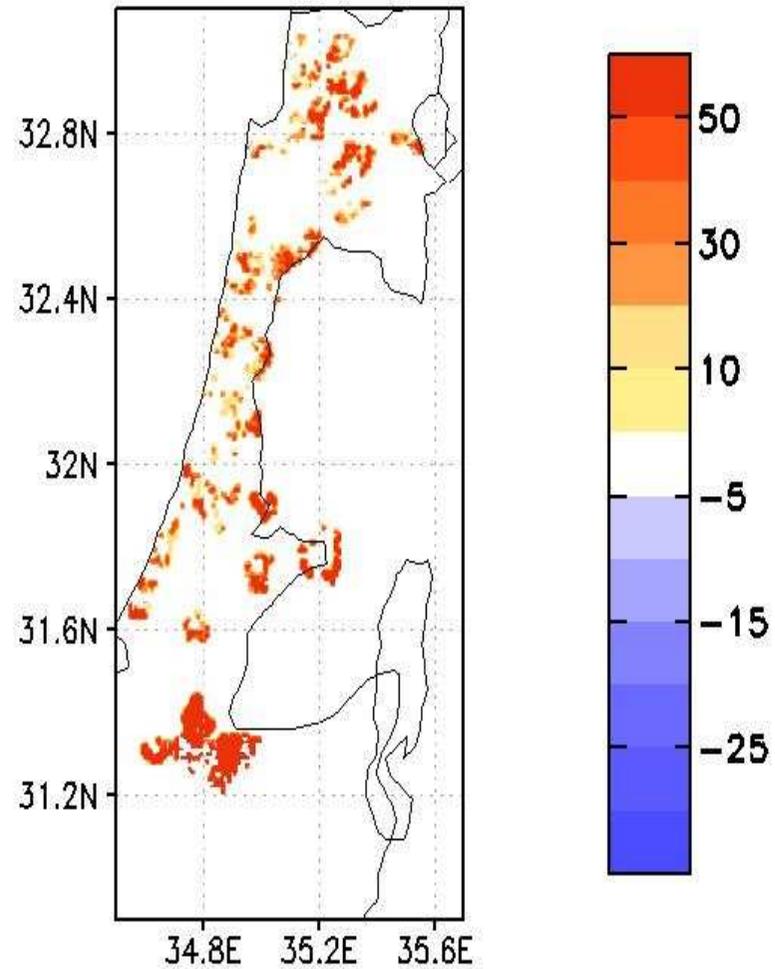


# Pathway to change

Mean differences in surface albedo

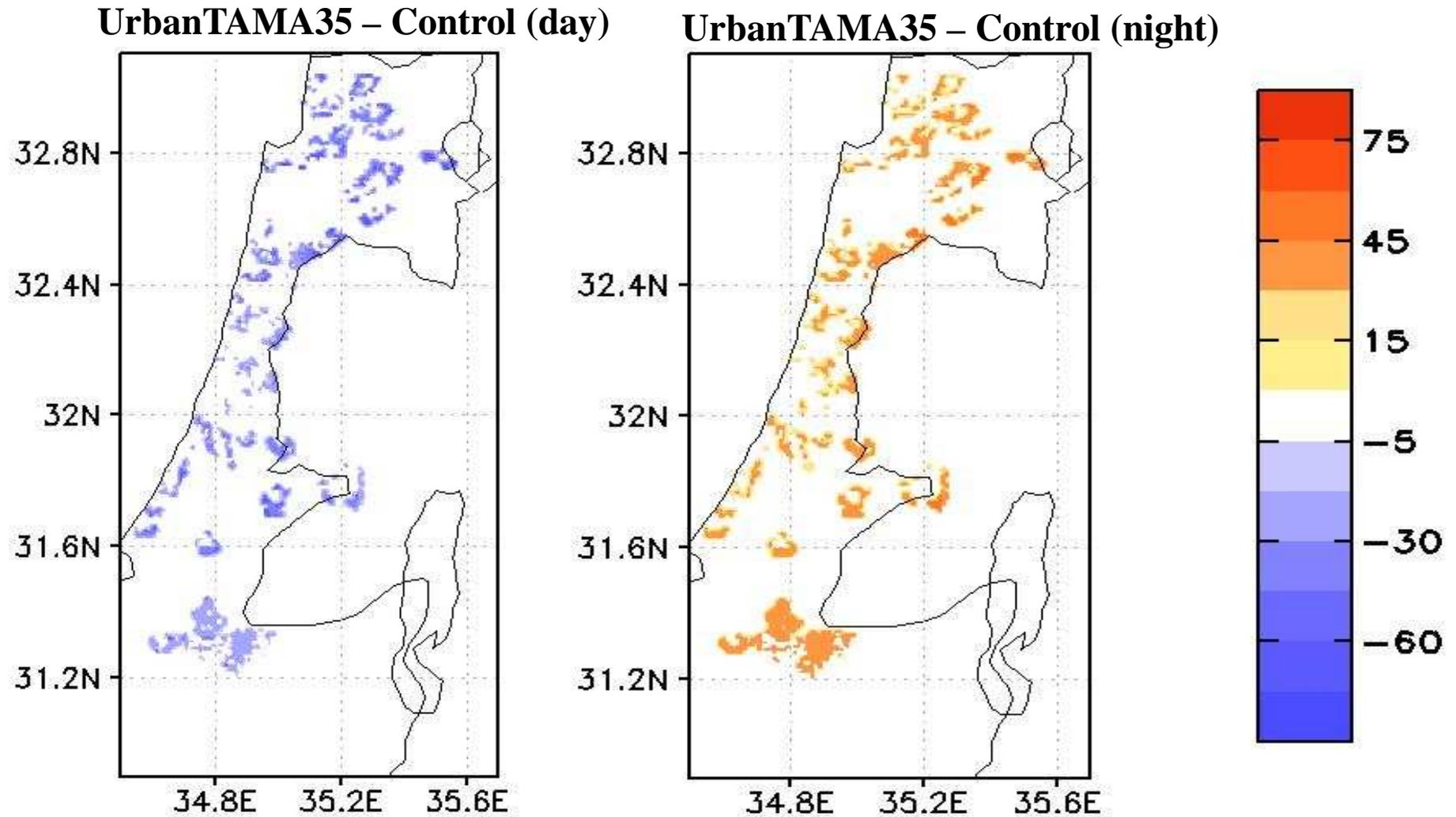


incident shortwave radiation  
( $SW\downarrow * [1 - \text{albedo}]$ ;  $W\ m^{-2}$ )



# Effect of LULCC on surface energy fluxes

## $\Delta$ Sensible heat flux

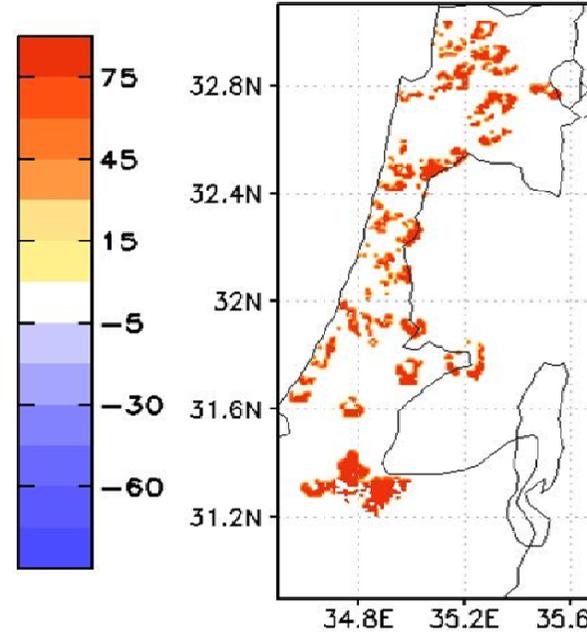
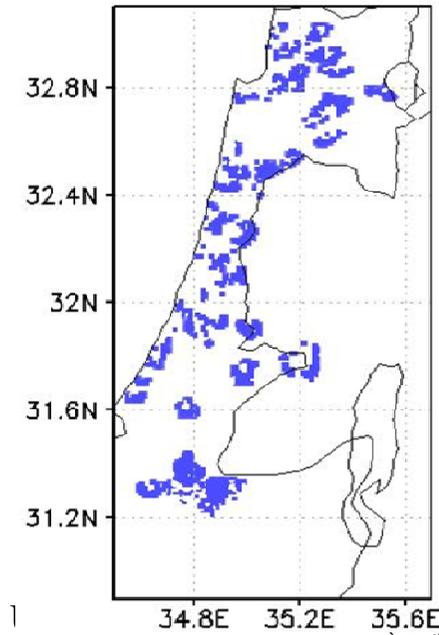


\* Negative values represent downward flux

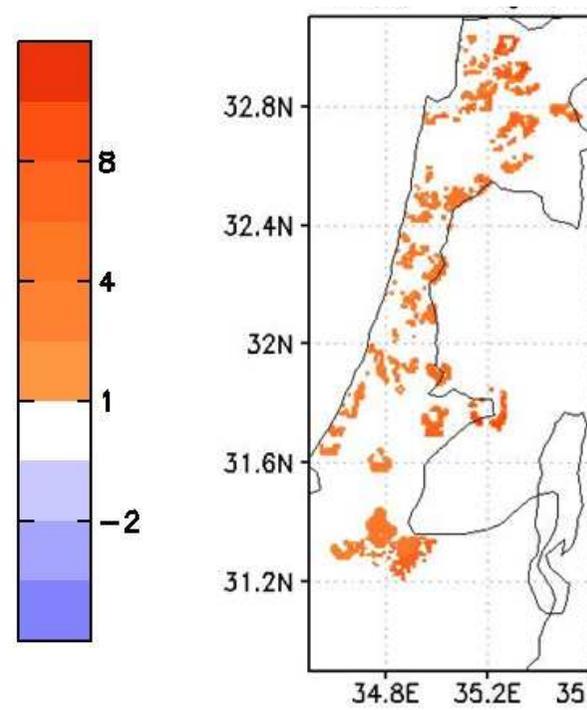
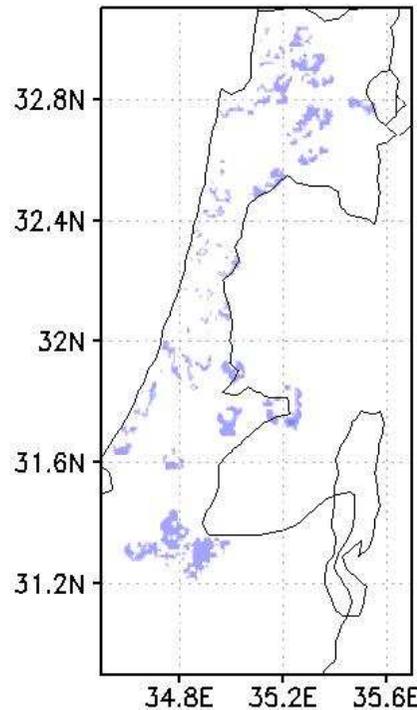
$\Delta$  Storage  
(G)

UrbanTAMA35 – Control (day)

UrbanTAMA35 – Control (night)



$\Delta$  LW  
emission



\* Negative values  
represent downward  
flux

# Conclusions

- ✓ Overall  $\overline{\Delta T} \Rightarrow 0.4-0.8$  °C, with Max  $\Delta T=3.5$  °C  
[similar to projected climate change]
- ✓ Spatially, temperature differences show a N-S and E-W gradient,
  - ➔ Climate & pre-urban land cover play a significant role in determining the impact
- ✓ UHI is the result of increased storage, due to changes in albedo and replacement of vegetated landscape with urban infrastructure

## Future work

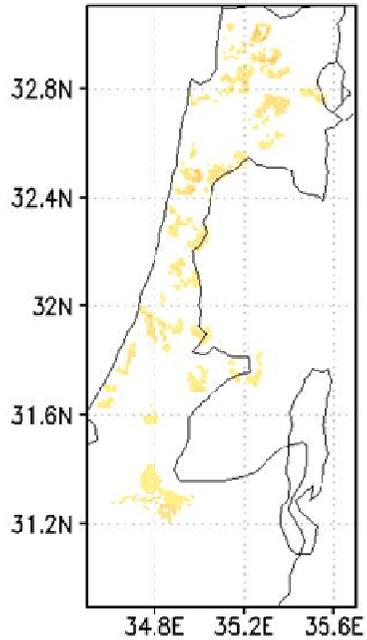
- Longer time scales – seasonal & yearly analyses.
- Finer resolution simulations to allow intra-urban spatial patterns of small cities expected to grow and cross-urban comparison along the climatic gradient.
- Evaluate geographically appropriate adaptation and mitigation strategies.
- Evaluate potential impacts:
  - Energy consumption
  - Changes in the temporal and spatial patterns of heat stress conditions, and thermal comfort

**Thank You**

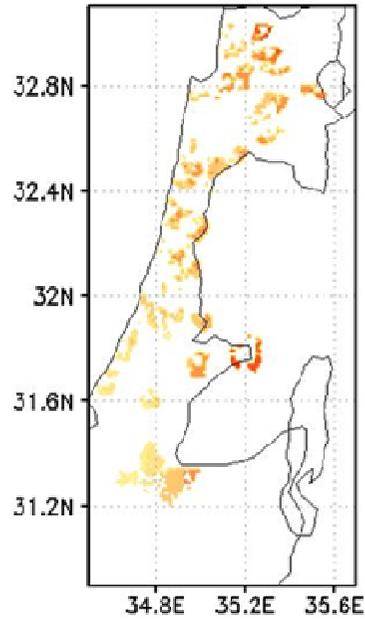


# UHI temporal development

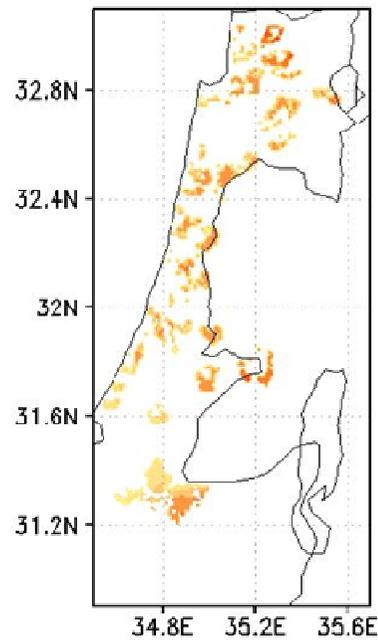
(a) UrbanTAMA35 – Control 18:00



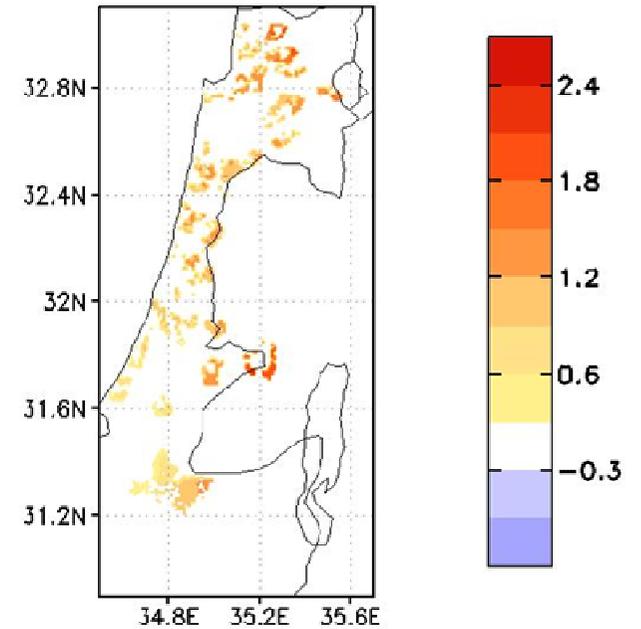
(b) UrbanTAMA35 – Control 21:00



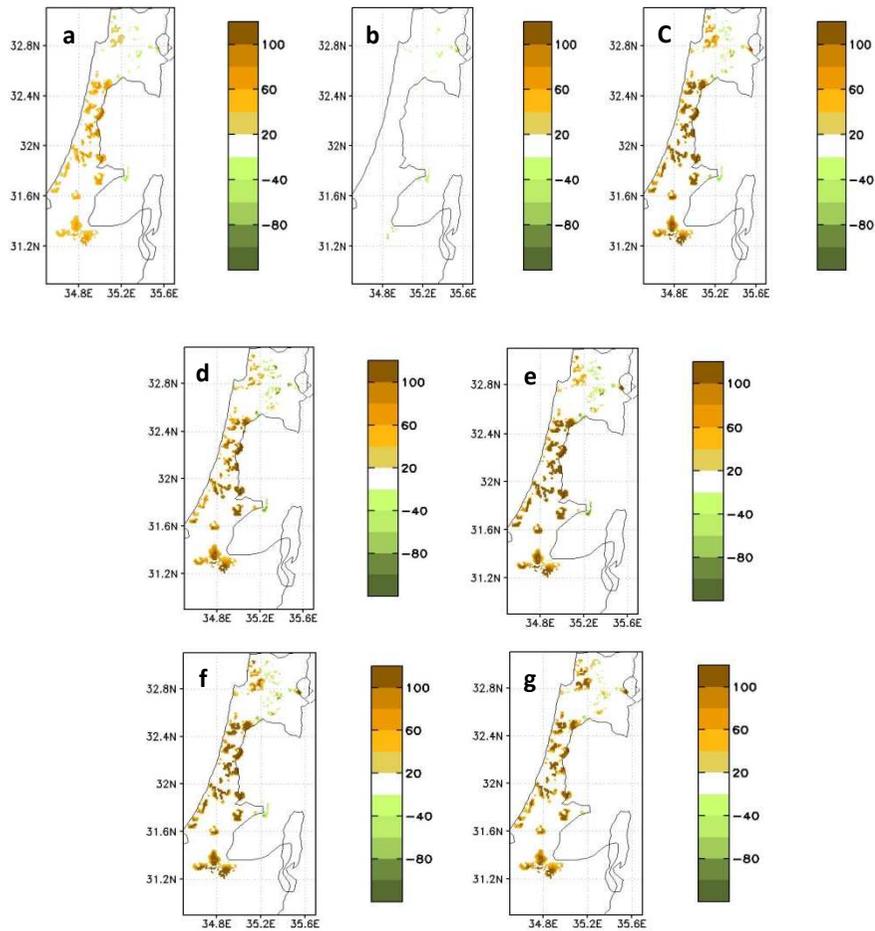
(c) UrbanTAMA35 – Control 00:00



(d) UrbanTAMA35 – Control 03:00



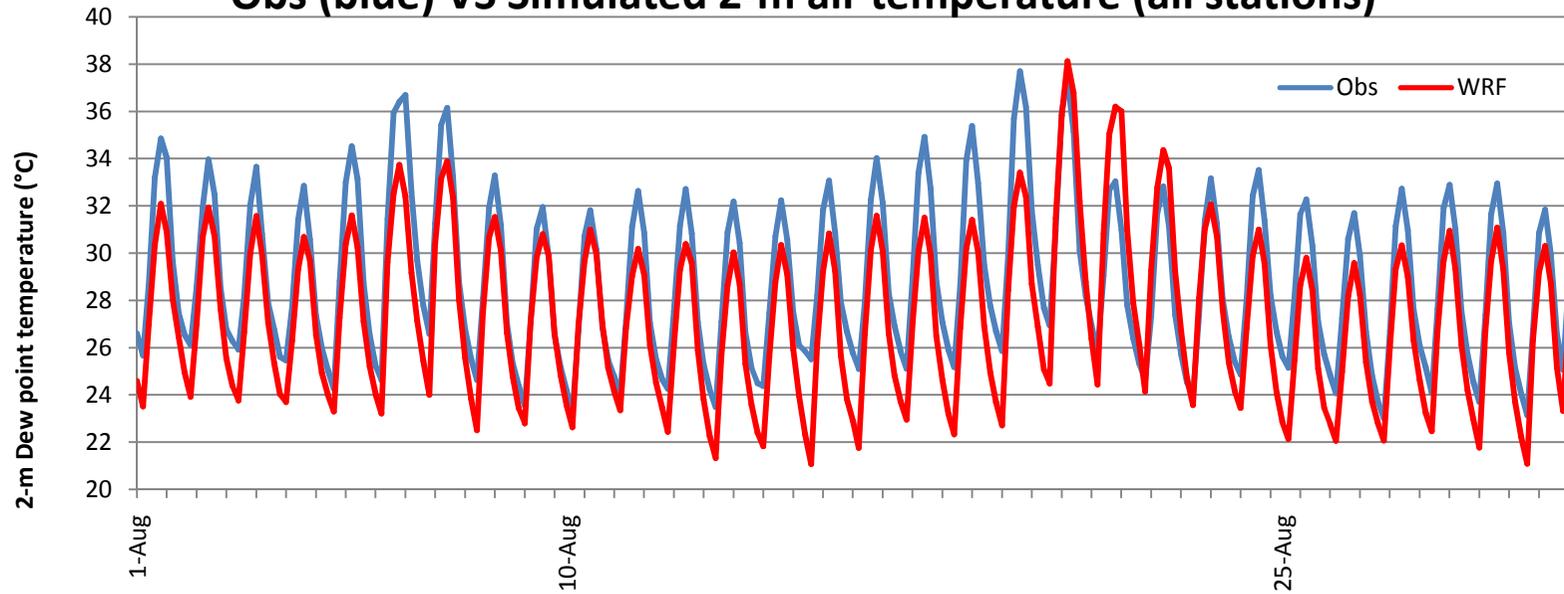
# PBL



WRF simulated averaged planetary boundary layer height differences between the urban expansion TAMA35 scenario and the August 2010 control (in m): (a) average across all times; (b) for day-time hours; (c) for nighttime hours; (d) for 18Z (20:00LST); (e) for 21Z (23:00LST); (f) for 00Z (02:00LST); (g) for 03:00 (05:00LST)

# Results: Model evaluation

## Obs (blue) VS Simulated 2-m air temperature (all stations)



## Obs (blue) VS Simulated Dew-Point temperature (all stations)

