A study on MM5 sensitivity on surface characteristics

June 26, 2008

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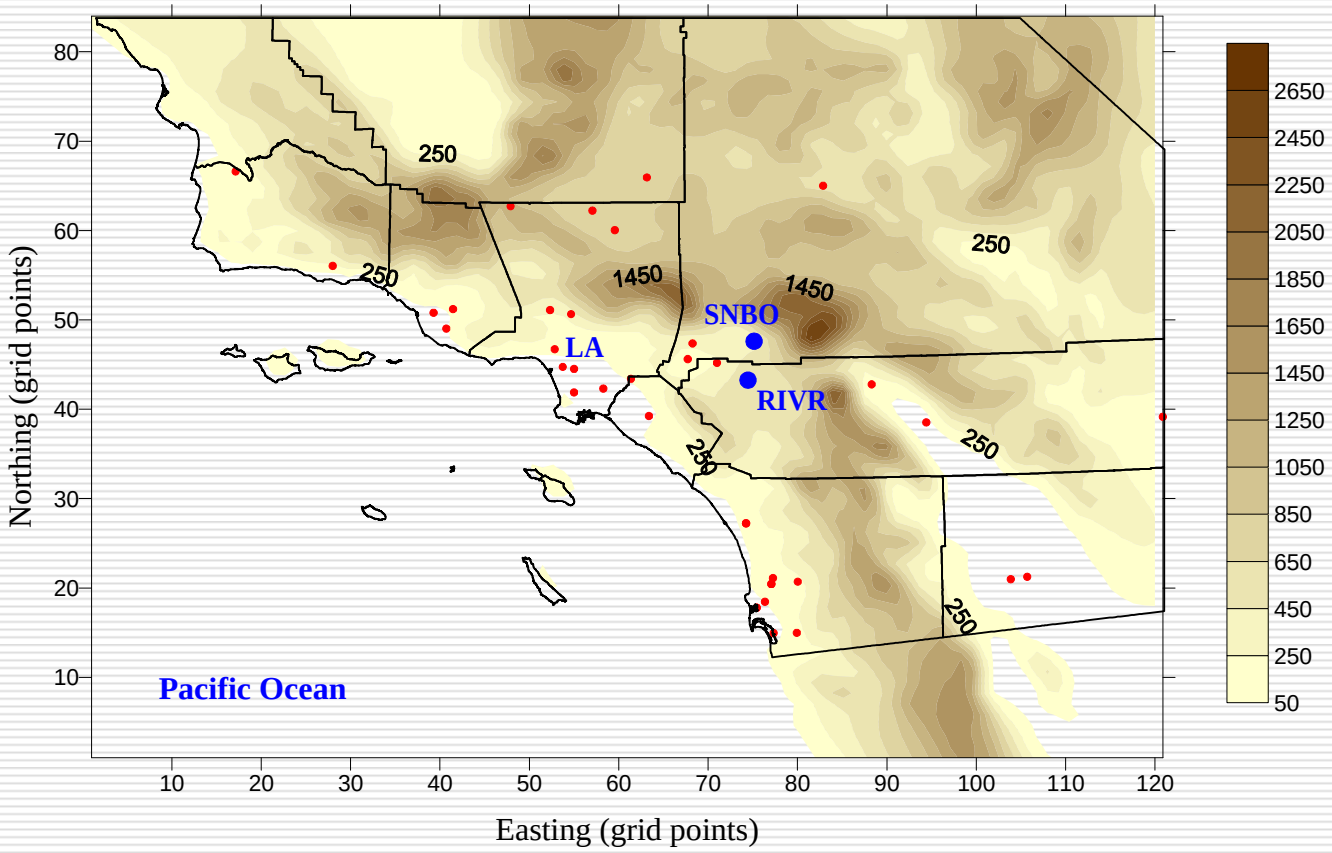
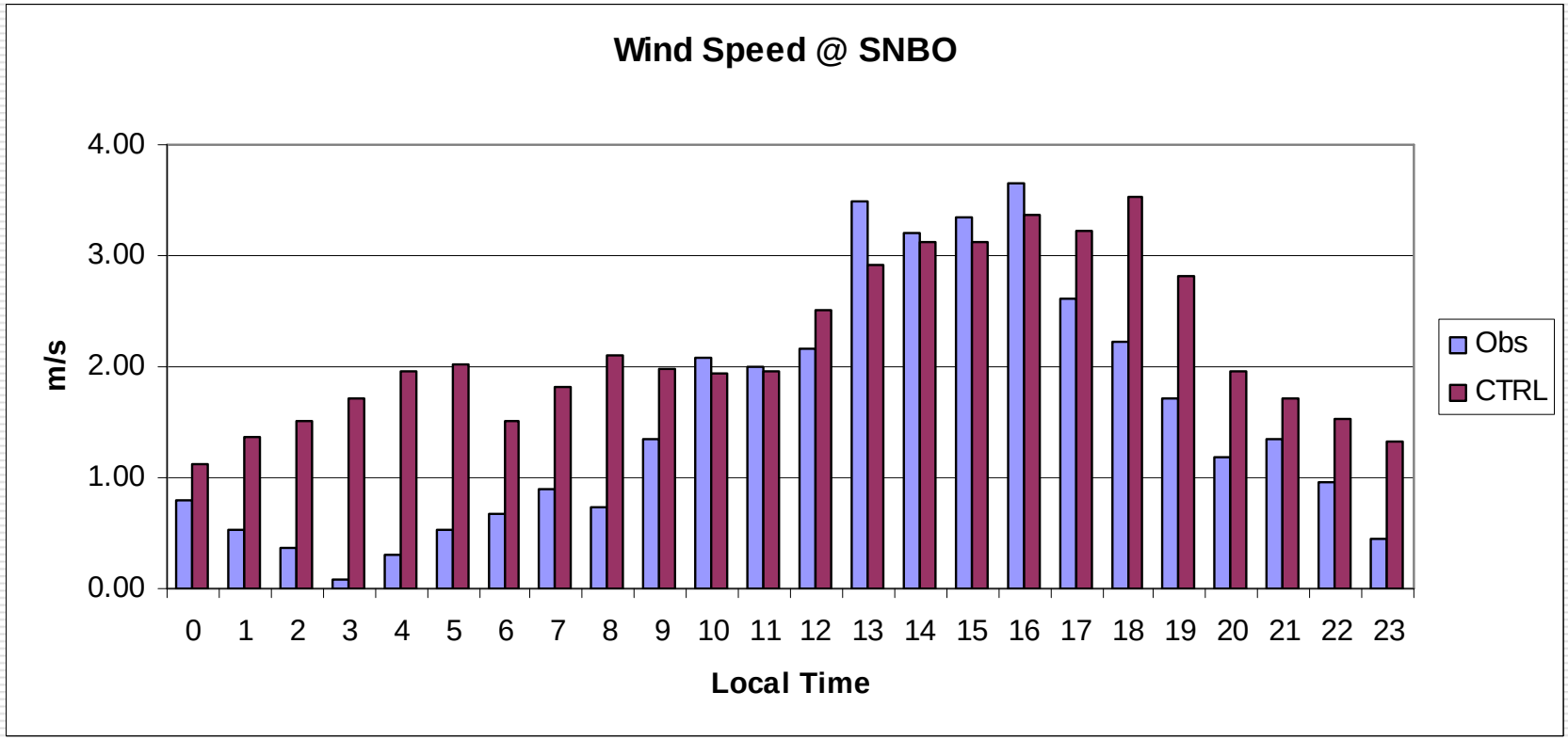
South Coast Air Quality Management District
Diamond Bar, CA

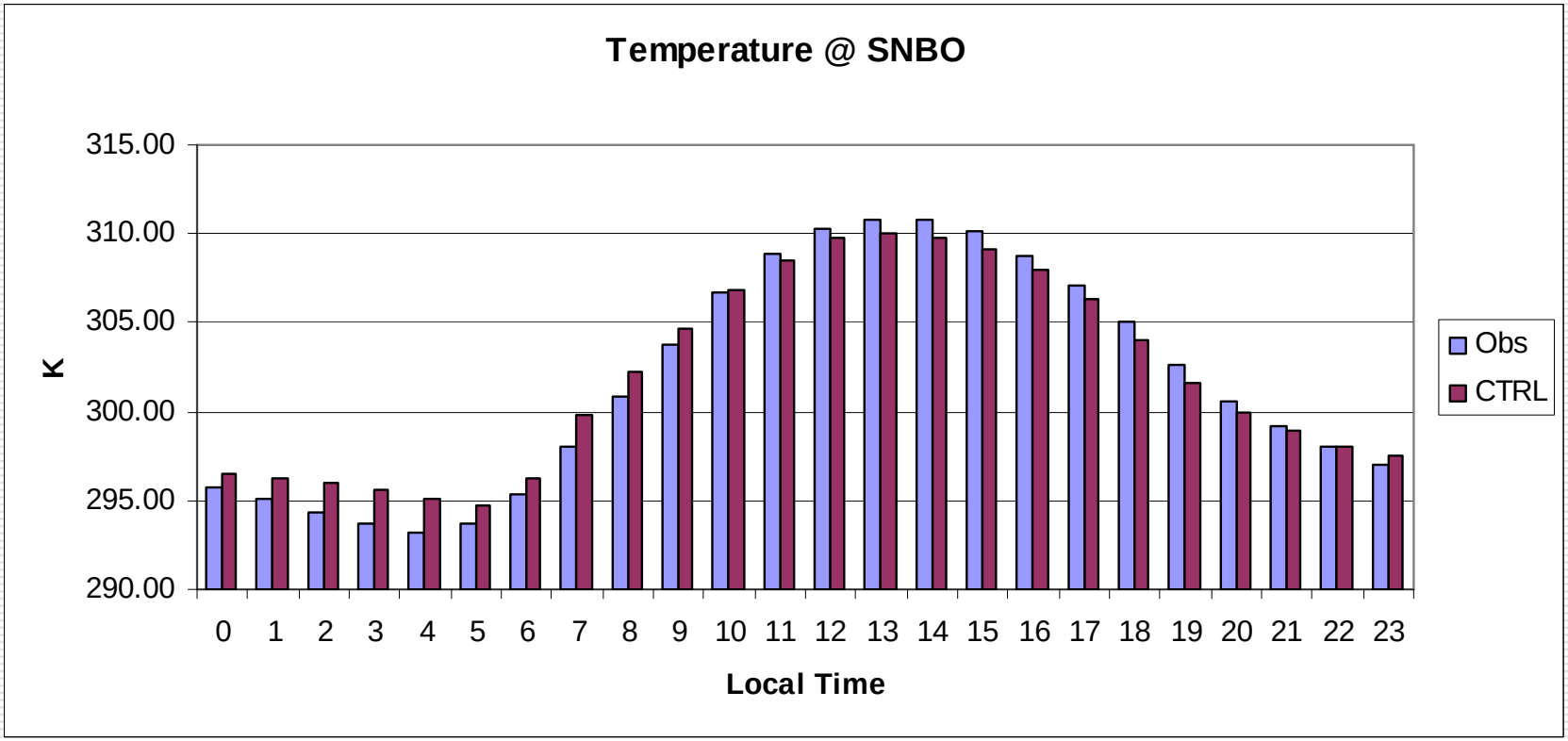
Topography in the South Coast Air Basin



Diurnal Variation of Wind



Diurnal Variation of Temperature



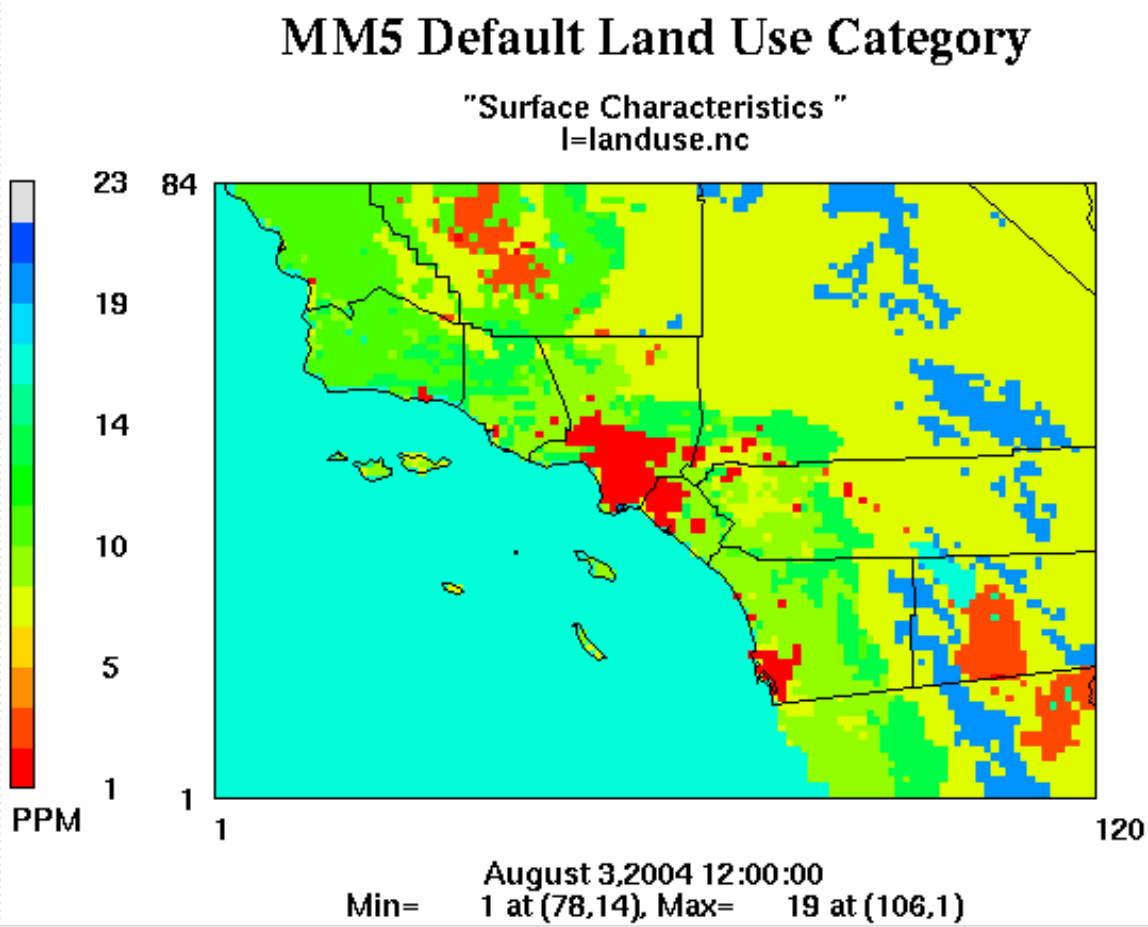
Approaches

- The influence of Land Use Changes

- Improved PBL scheme

The influence of Land Use Changes

MM5 Default Land Use (Δx=5 km)



Land Cover Index

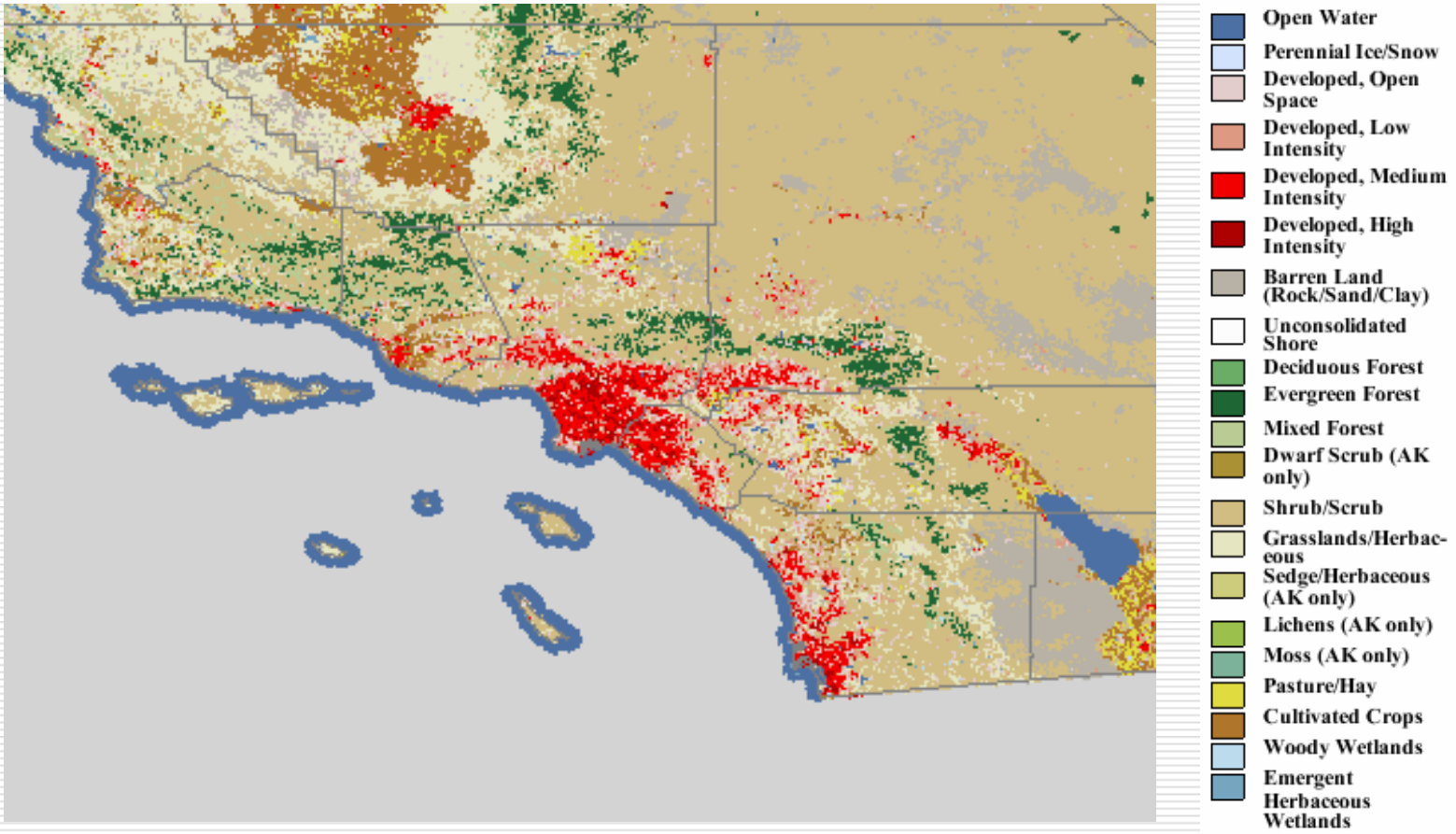
1: Urban

7: Grassland

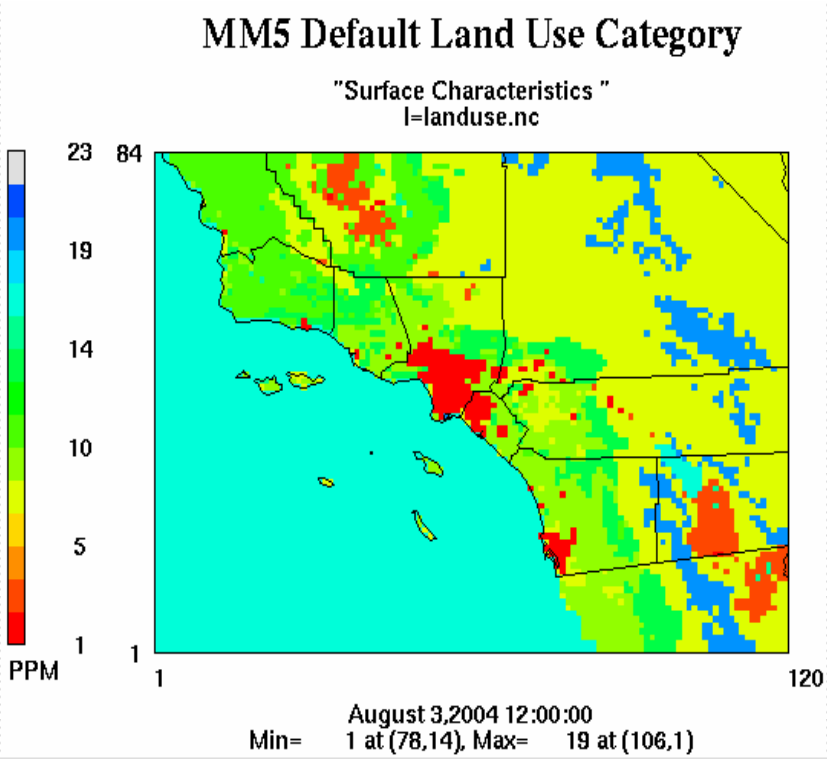
8: Shrubland

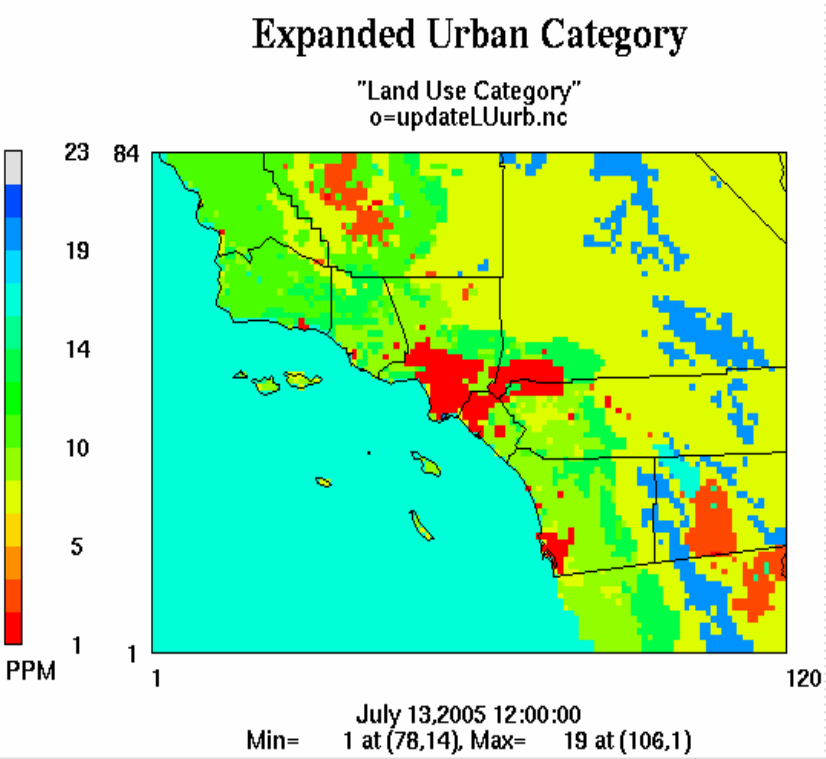
9: Mixed Shrub/Grass

National Land Cover Data 2001

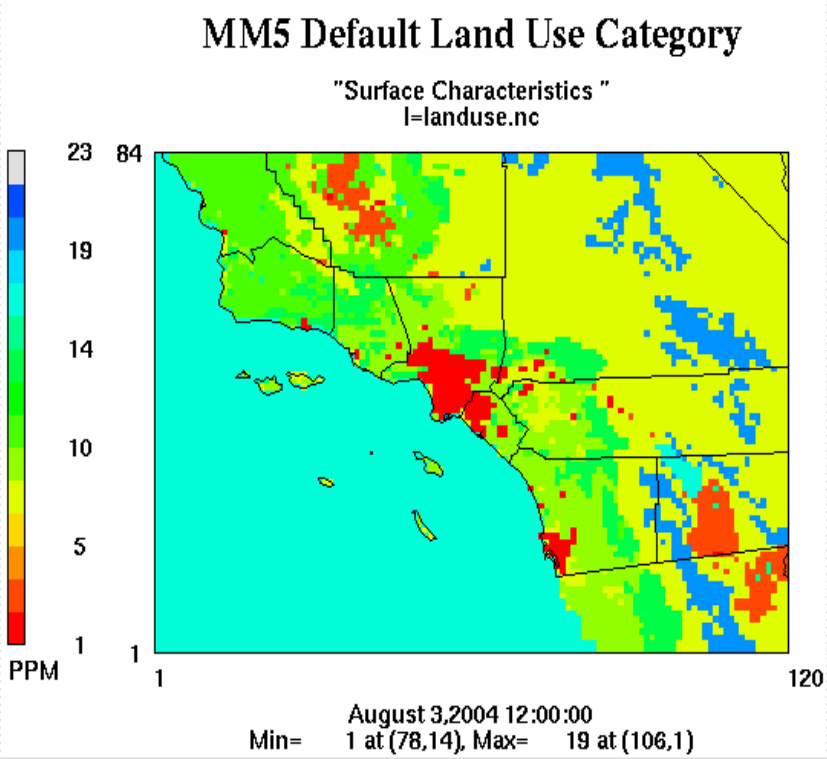


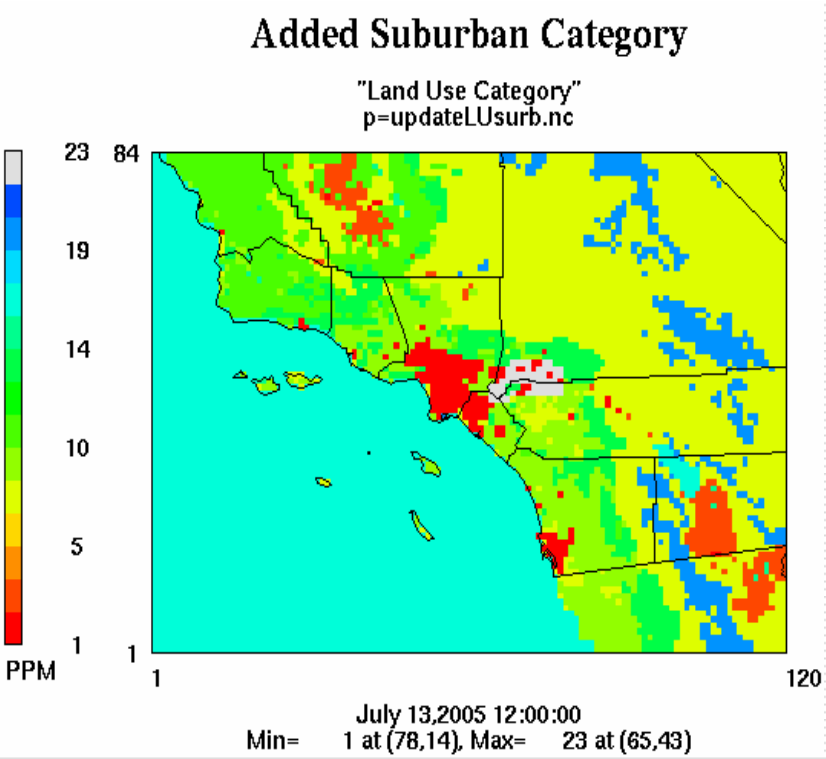
Expanded Urban Category





Added Suburban Category





Physical Parameters of LU categories

	Albedo	Soil Mositure Availability	Surface Emissivity	Surface Roughness Length	Thermal Inertia
	(%)	(%)	(% at 9 µm)	(m)	(cal cm-2 K-1s-1/2)
Urban	15	10	88	0.80/1.50	0.03
Subruban	17	10	90	0.70	0.03
Grassland	19	15	96	0.12	0.03
Shrubland	22	10	90	0.10	0.03

MM5 Default Configuration

- First guess field: Eta 212 grid analysis output
- Two domains of which grid distances are 15, and 5 km, respectively
- The number of grids in the inner most domain: (121,85)
- The number of vertical layers = 30 with the lowest layer at approximately 10 m agl
- Blackadar PBL, 5 layer soil model, no cumulus parameterization, and cloud radiation scheme.

Sensitivity Runs

- Run1:
  - Control run with default LU categories
- Run5:
  - Expanded Urban category
  - $z_{0\ urban}$ = 1.5 m
  - $z_{0\ water}$ = 0.1 cm
- Run6:
  - New suburban category
  - $z_{0\ urban}$ = 1.5 m
  - $z_{0\ suburb}$ = 0.7 m
  - $z_{0\ water}$ = 0.1 cm
- Run7:
  - Expanded Urban category
  - Default parameters for all the category
  - $z_{0\ urban}$ = *0.8* m

Increase surface drag via z_0

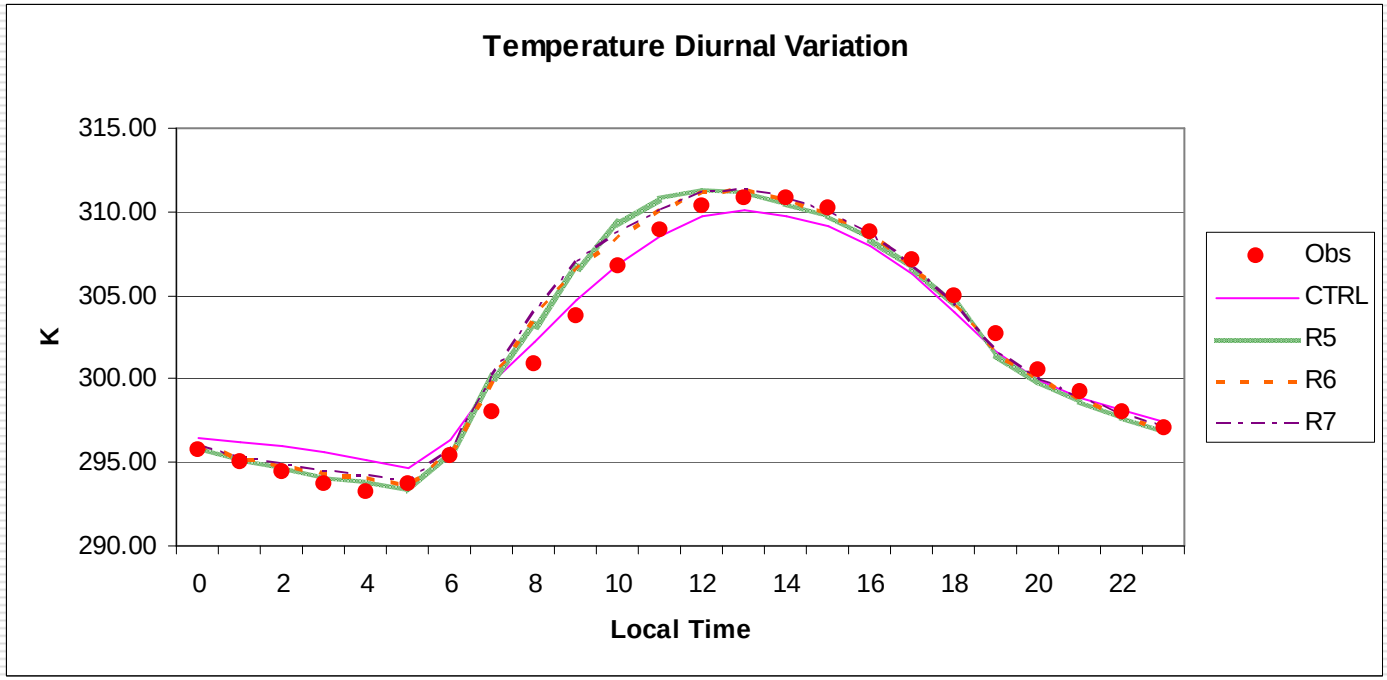
- Default z_0 values
  - Over the water: Charnock (1955) formula

$$z_0 = 0.032 u_*^2 / g$$

  - For the episode cases, z_0 ~< 0.03 cm

- Modifications
  - water: z_0= 0.1 cm

2 m Temperature at SNBO



R5: Expanded Urban, $z_{0\ urb}$ = 1.5 m, $z_{0\ w}$ = 0.1 cm
R6: Suburban, $z_{0\ urb}$ = 1.5 m, $z_{0\ suburb}$ = 0.7 m, $z_{0\ w}$ = 0.1 cm
R7: Expanded Urban, z_{0urb}=0.8m (default)

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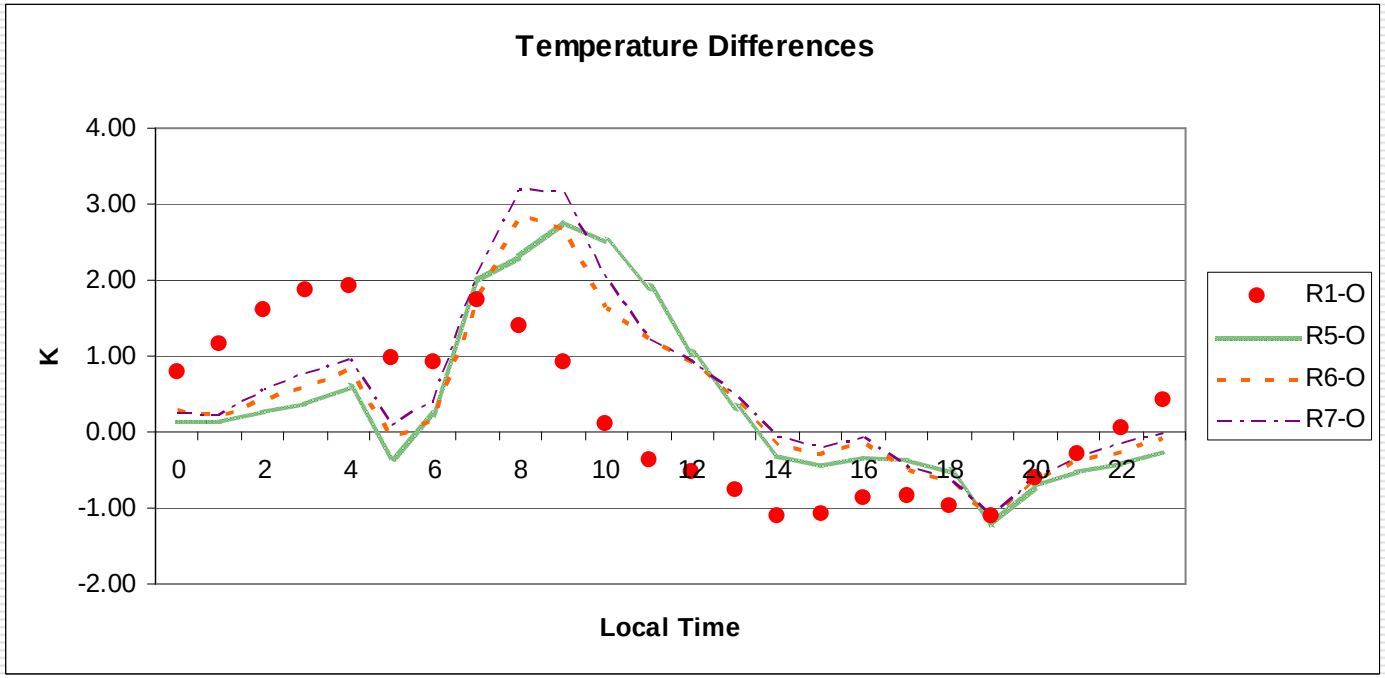

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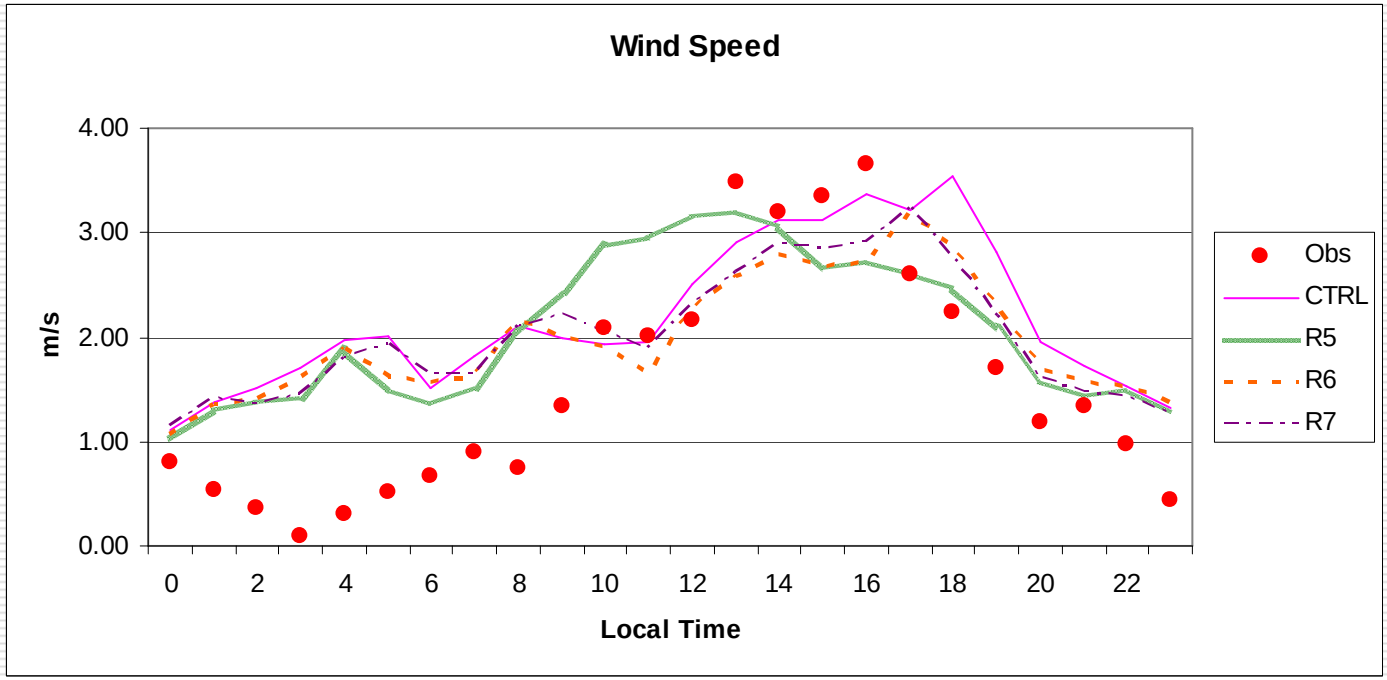
10 m Wind Speed at SNBO



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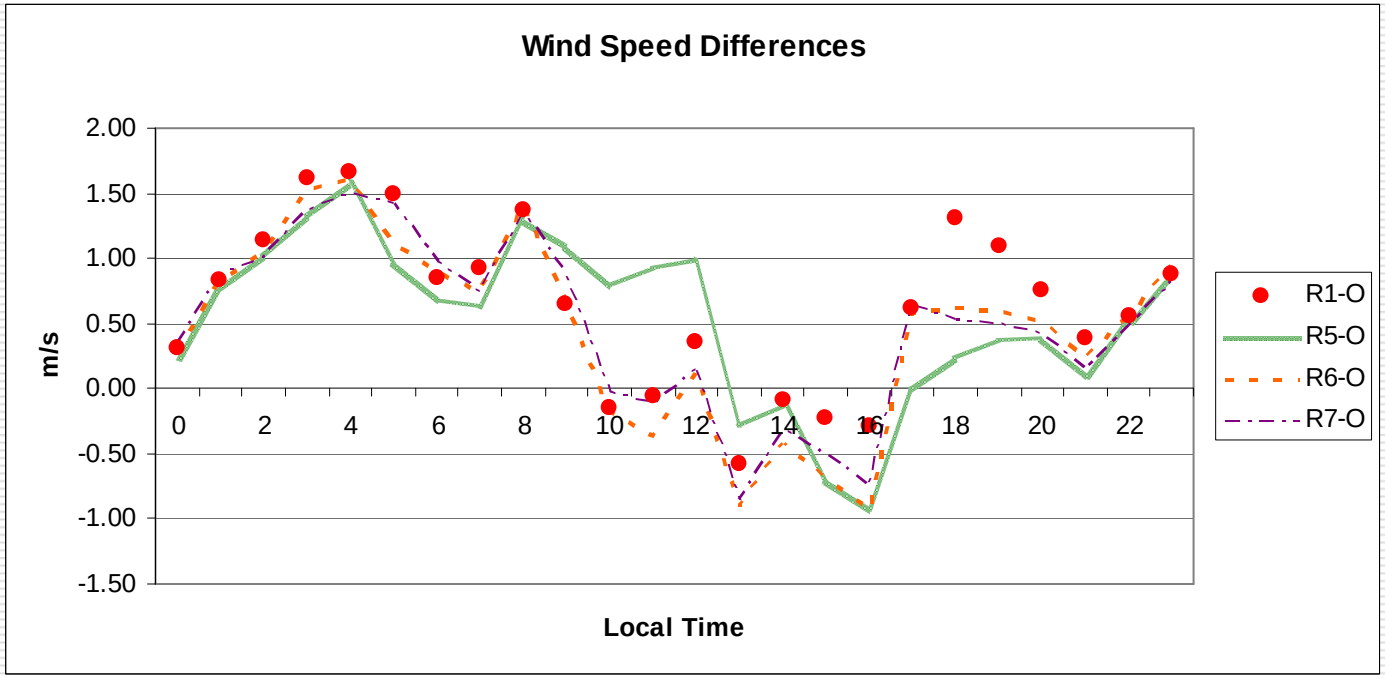

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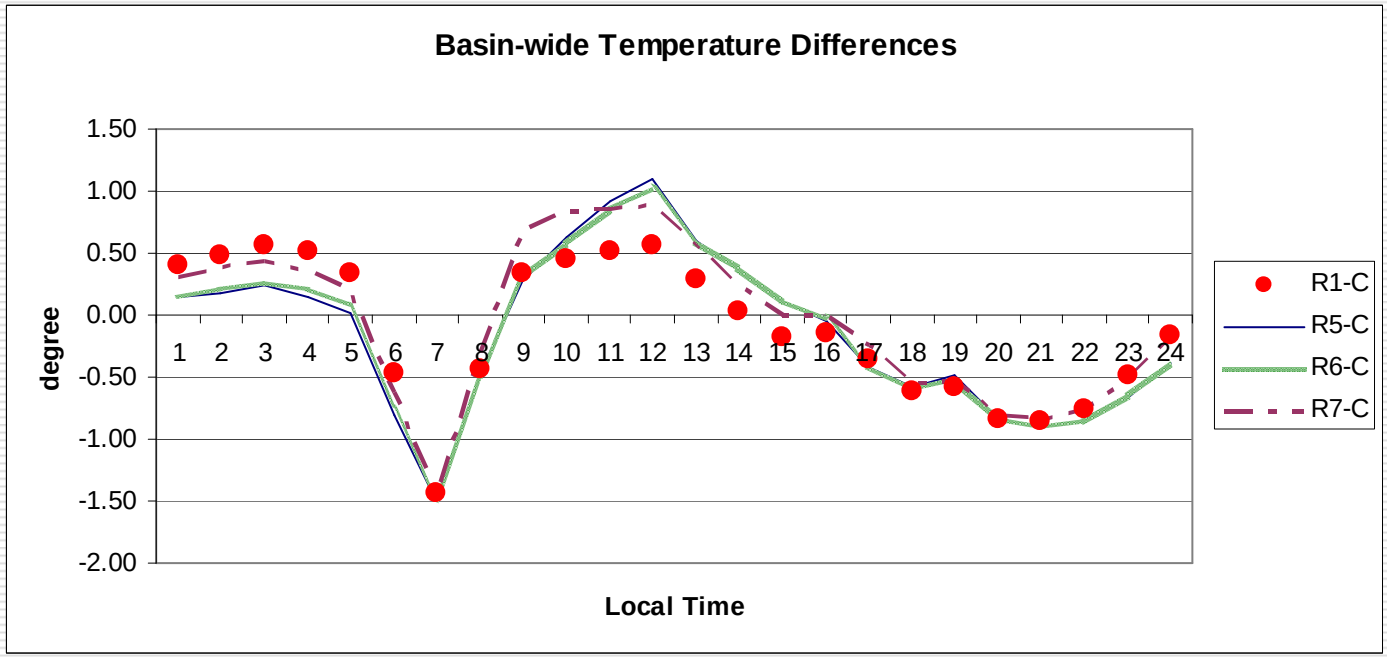
Basin-wide Averaged Temperature



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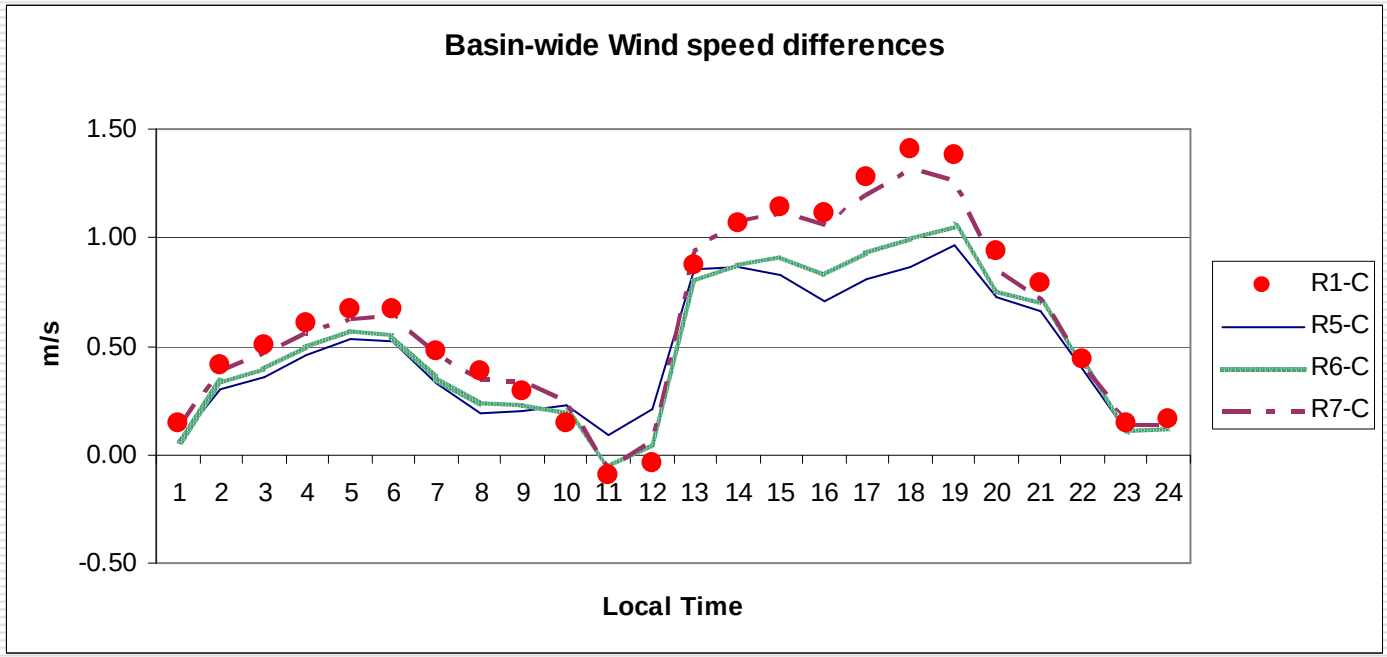
Basin-wide Averaged Wind Speed



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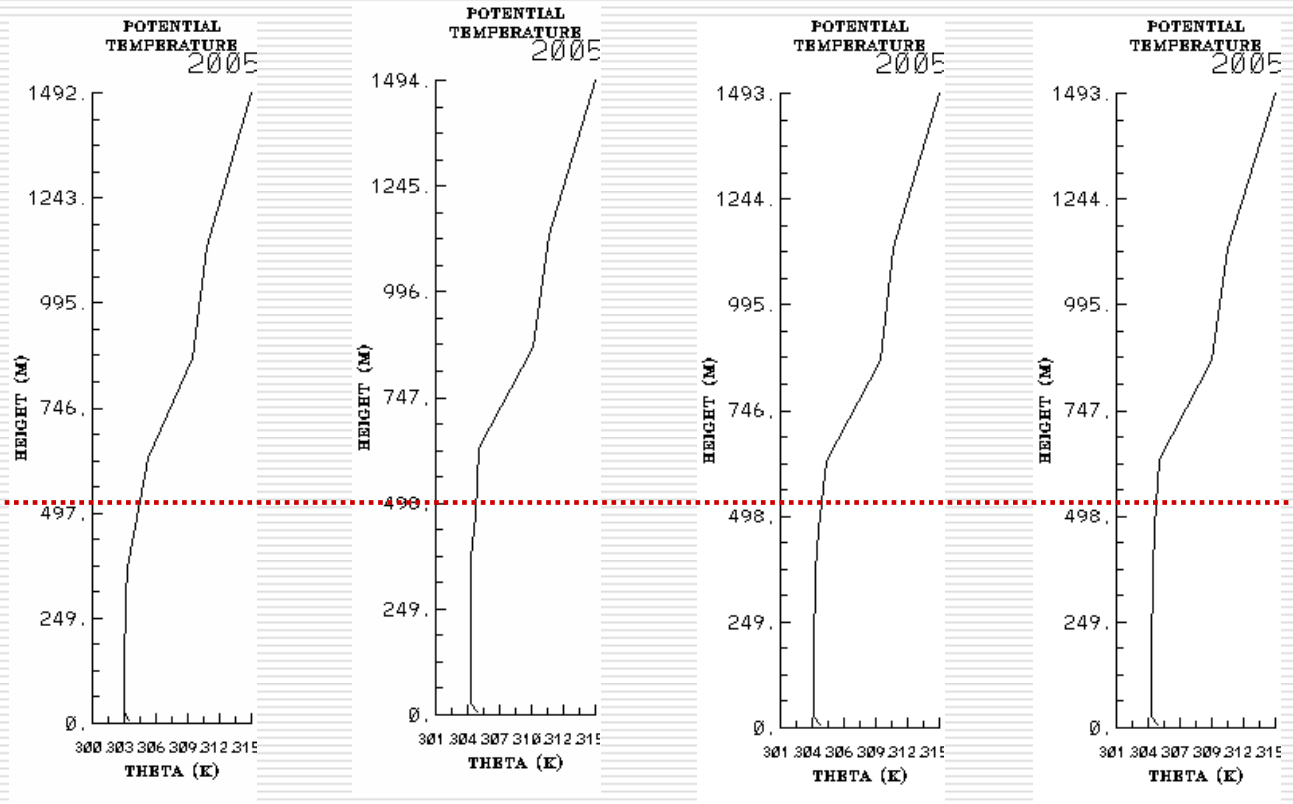
1000 PST Jul 15, 2005 at Ontario

Run1 **Run5** **Run6** **Run7**



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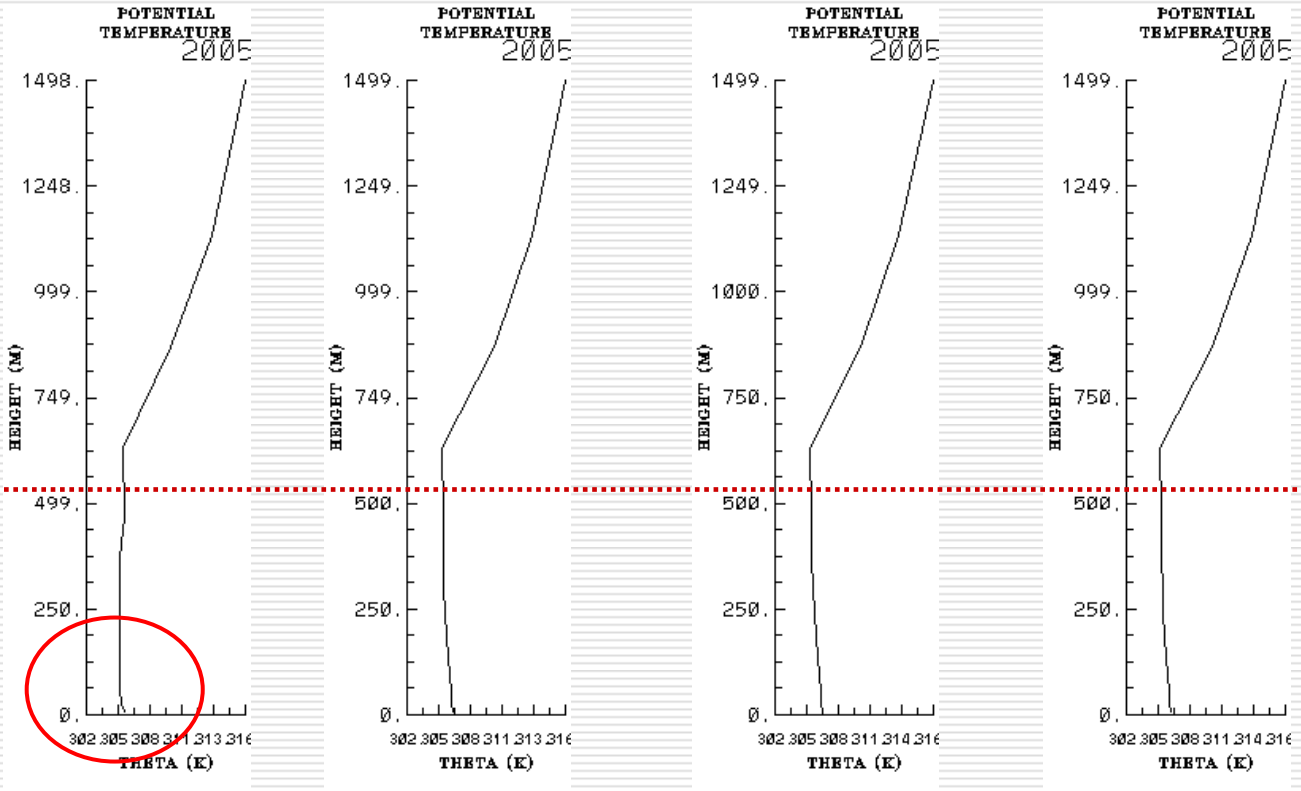
R7: Expanded Urban, z_{0urb}=0.8m (default)

1600 PST Jul 15, 2005 at Ontario

Run1 **Run5** **Run6** **Run7**



Super-adiabatic layer

R5: Expanded Urban, $z_{0\ urb}$ = 1.5 m, $z_{0\ w}$ = 0.1 cm
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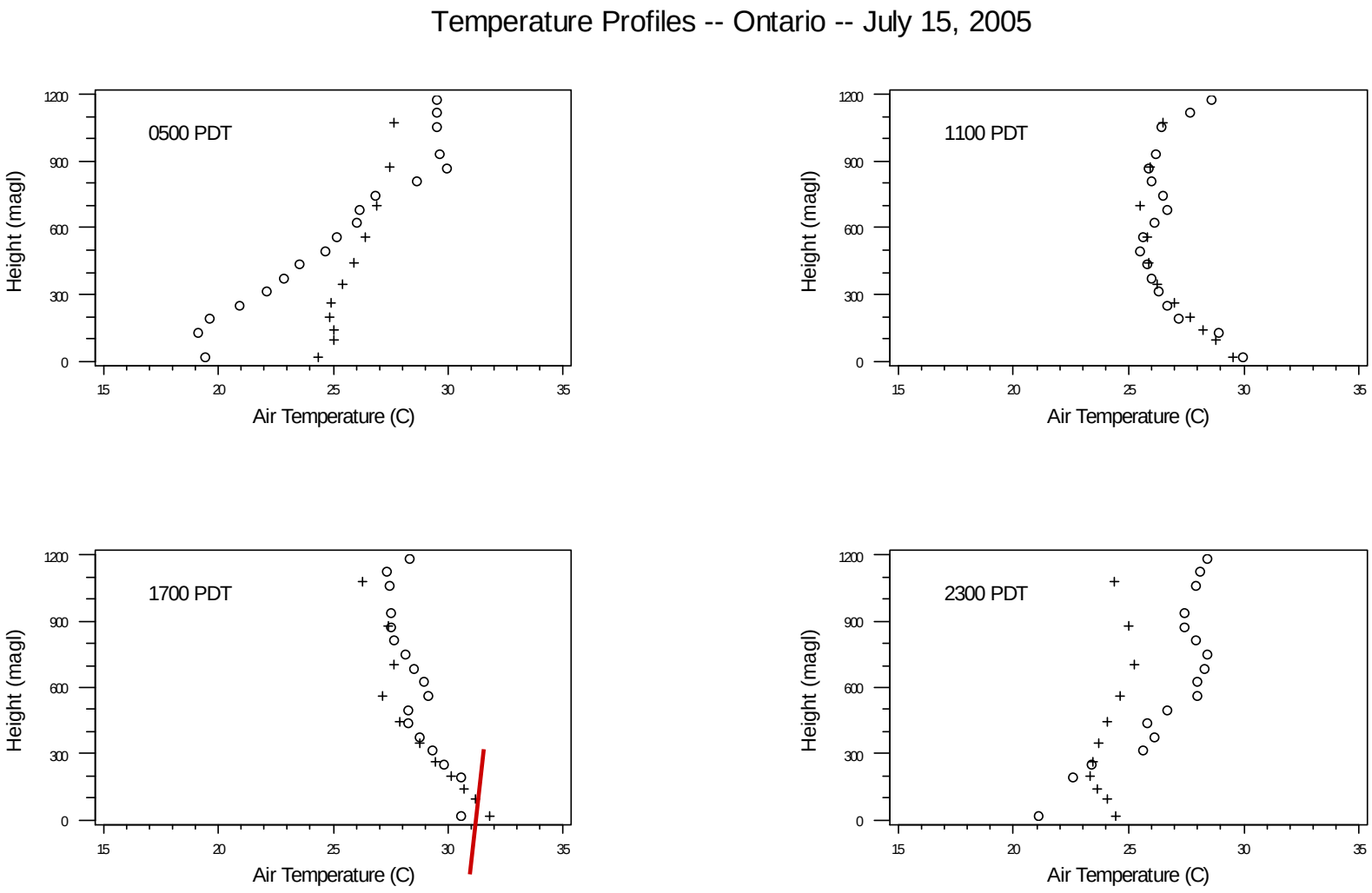
R7: Expanded Urban, z_{0urb}=0.8m (default)



Measured (circles) and simulated (crosses) air temperature profiles for July 15, 2005 at Ontario – ETA PBL module (From Bruce Jackson)

Improved PBL Scheme

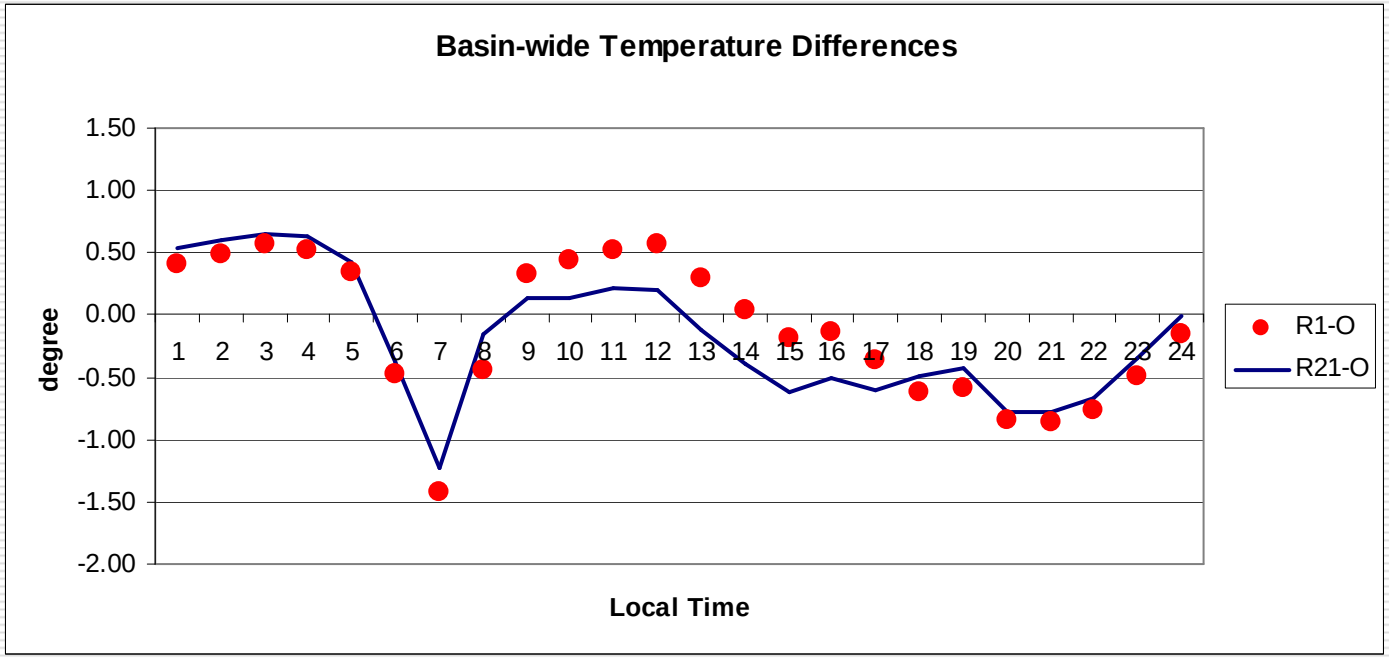
Modified Blackadar Scheme

- Ri_c = 0.25 in the Surface Layer, not proportional to a layer thickness
- Length scale $l = \Delta z$, not $l = 100\ m$
- K_z based on Zhang & Anthes (1982) for the stable period

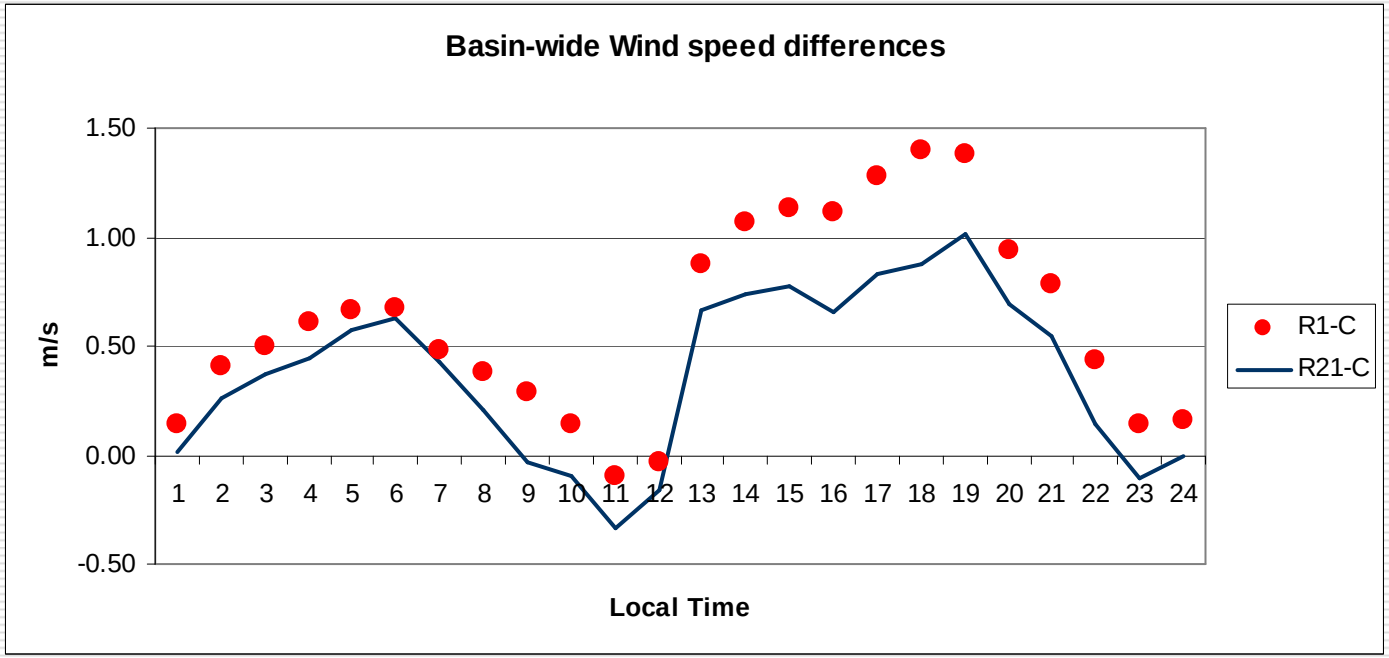
$$K_z = K_0 + S_i (kl)^2 \frac{R_{ic} - R_i}{R_i}$$

- Using θ rather than θ_v in computing Ri_b
- Mass exchange coefficient was applied to θ and q as well as u and v

Control (Run1) vs. Mod Blackadar (Run21)



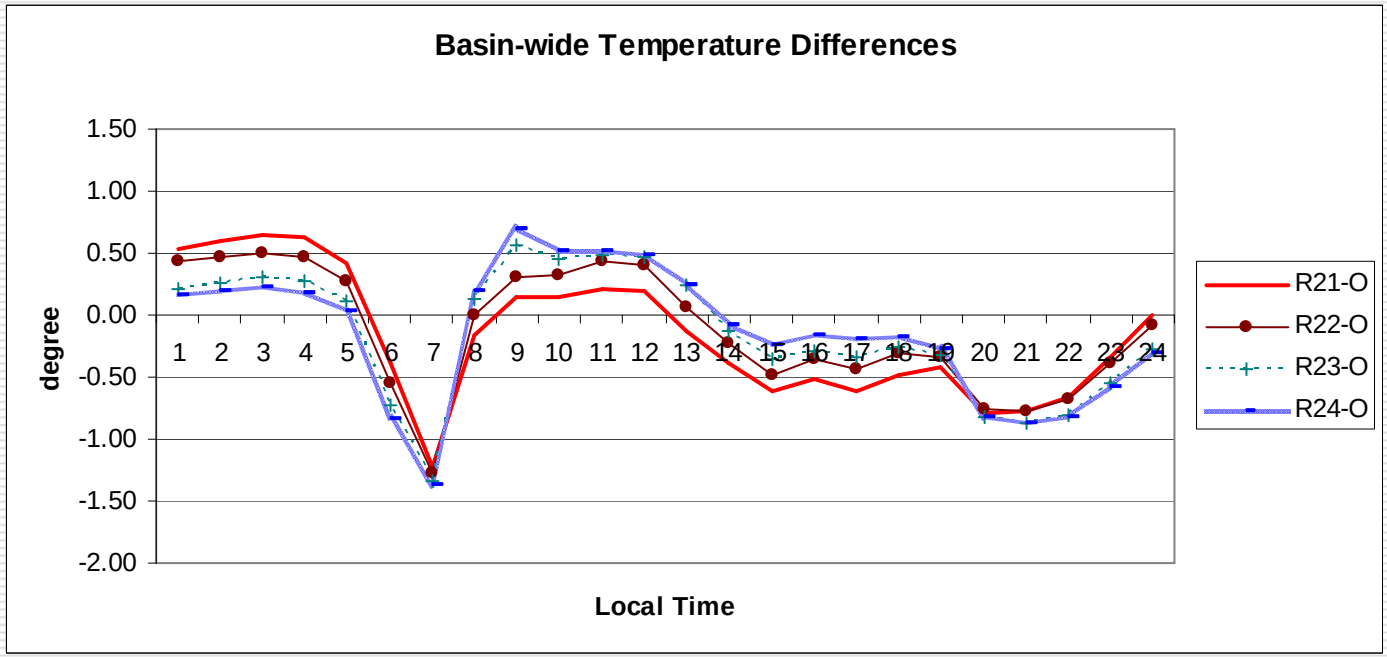
Control (Run1) vs. Mod Blackadar (Run21)



Sensitivity Runs with Modified Blackadar scheme

- Run21:
  - Modified Blackadar scheme
  - Same as the Control run, Run1
- Run22:
  - Modified Blackadar scheme
  - Expanded Urban category
  - Default parameters for all the category
- Run23:
  - Modified Blackadar scheme
  - New suburban category
  - $z_{0\ urban}$ = 1.5 m
  - $z_{0\ suburb}$ = 0.7 m
- Run24:
  - Modified Blackadar scheme
  - Expanded Urban category
  - $z_{0\ urban}$ = 1.5 m

Basin-wide Averaged Temperature



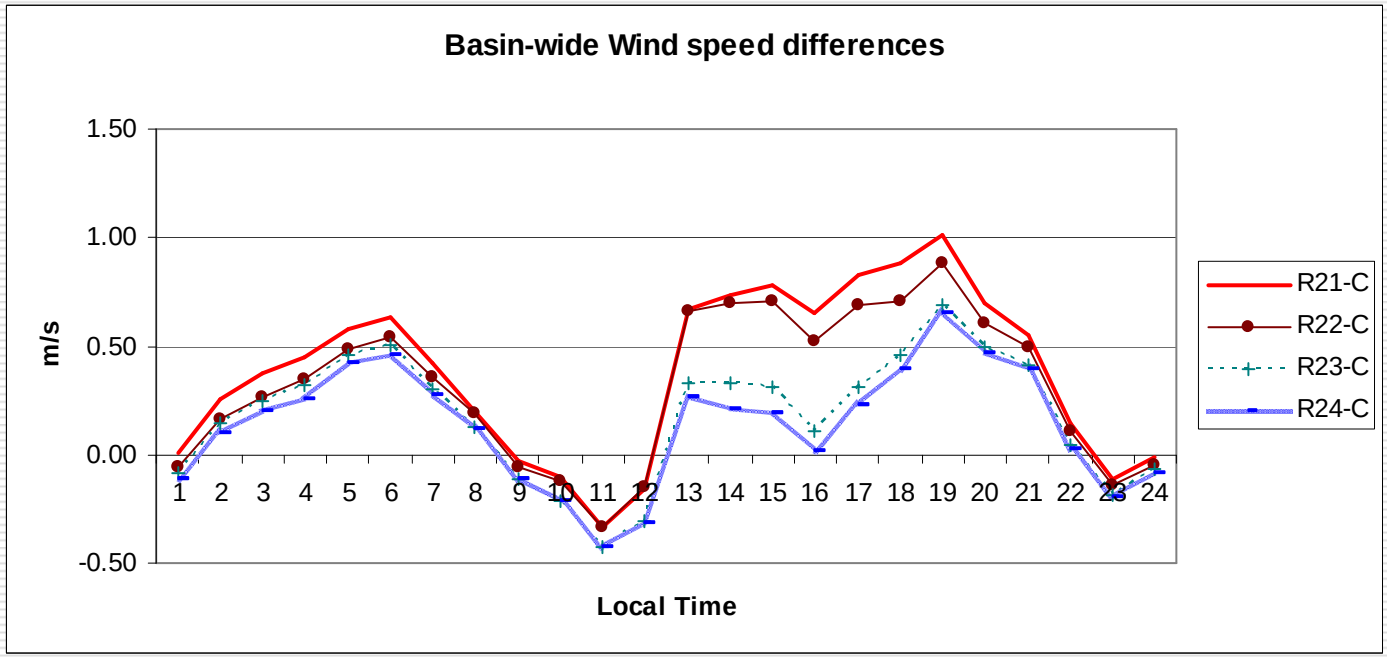
R21: Mod Blackadar Default

R22: Expanded Urban, z_{0urb}=0.8m

R23: Suburban, $z_{0\ urb}$ = 1.5 m, $z_{0\ suburb}$ = 0.7 m

R24: Expanded Urban, $z_{0\ urb}$ = 1.5 m

Basin-wide Averaged Wind Speed



R21: Mod Blackadar Default

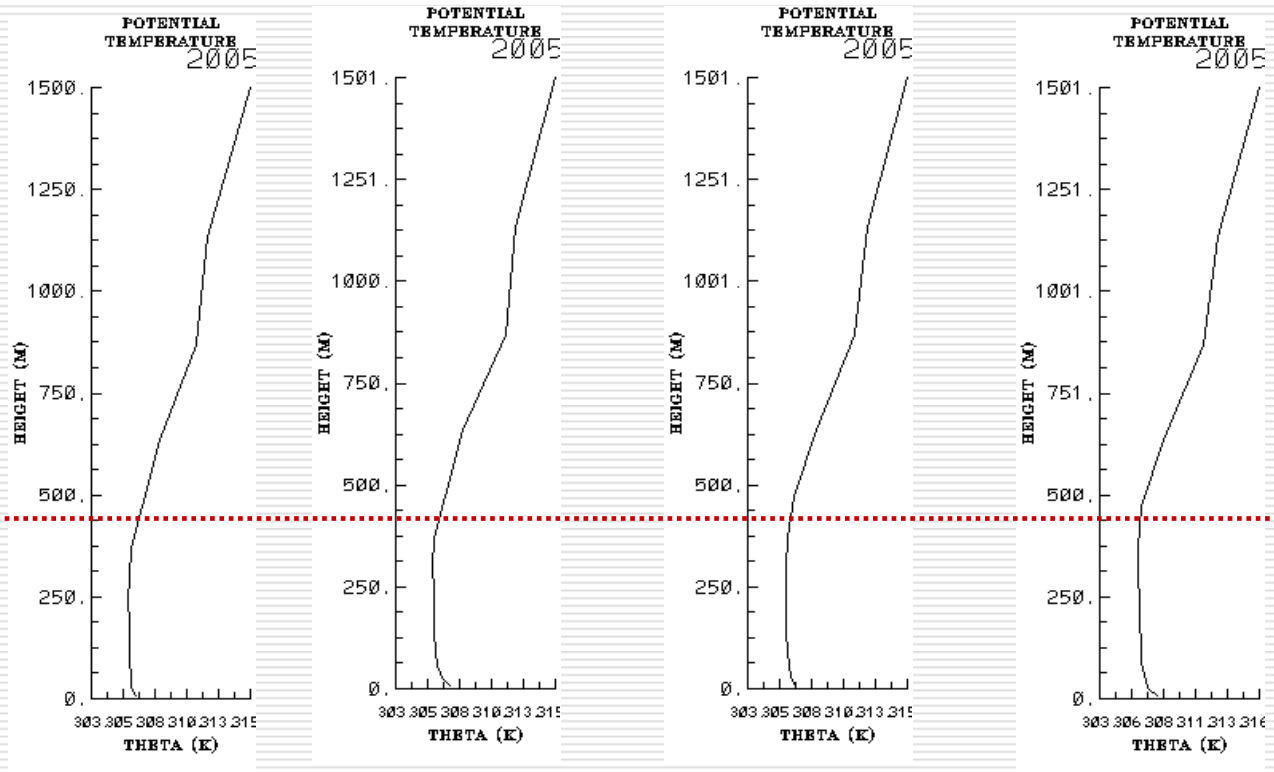
R22: Expanded Urban, z_{0urb}=0.8m

R23: Suburban, $z_{0\ urb}$ = 1.5 m, $z_{0\ suburb}$ = 0.7 m

R24: Expanded Urban, $z_{0\ urb}$ = 1.5 m

1600 PST Jul 16, 2005 at Ontario

Run21 **Run22** **Run23** **Run24**



R21: Mod Blackadar Default

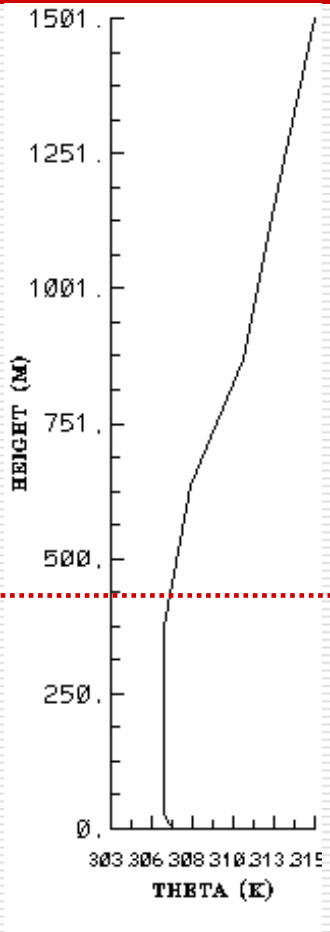
R22: Expanded Urban, z_{0urb}=0.8m

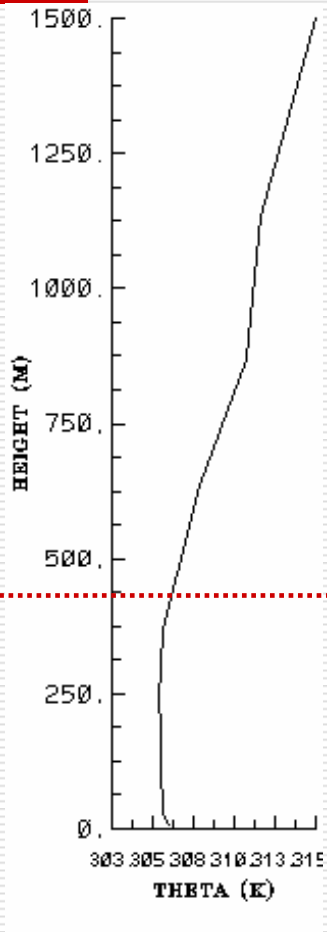
R23: Suburban, $z_{0\ urb}$ = 1.5 m, $z_{0\ suburb}$ = 0.7 m

R24: Expanded Urban, $z_{0\ urb}$ = 1.5 m

Control (Run1) vs. Mod Blackadar (Run21)

1600 PST Jul 16, 2005

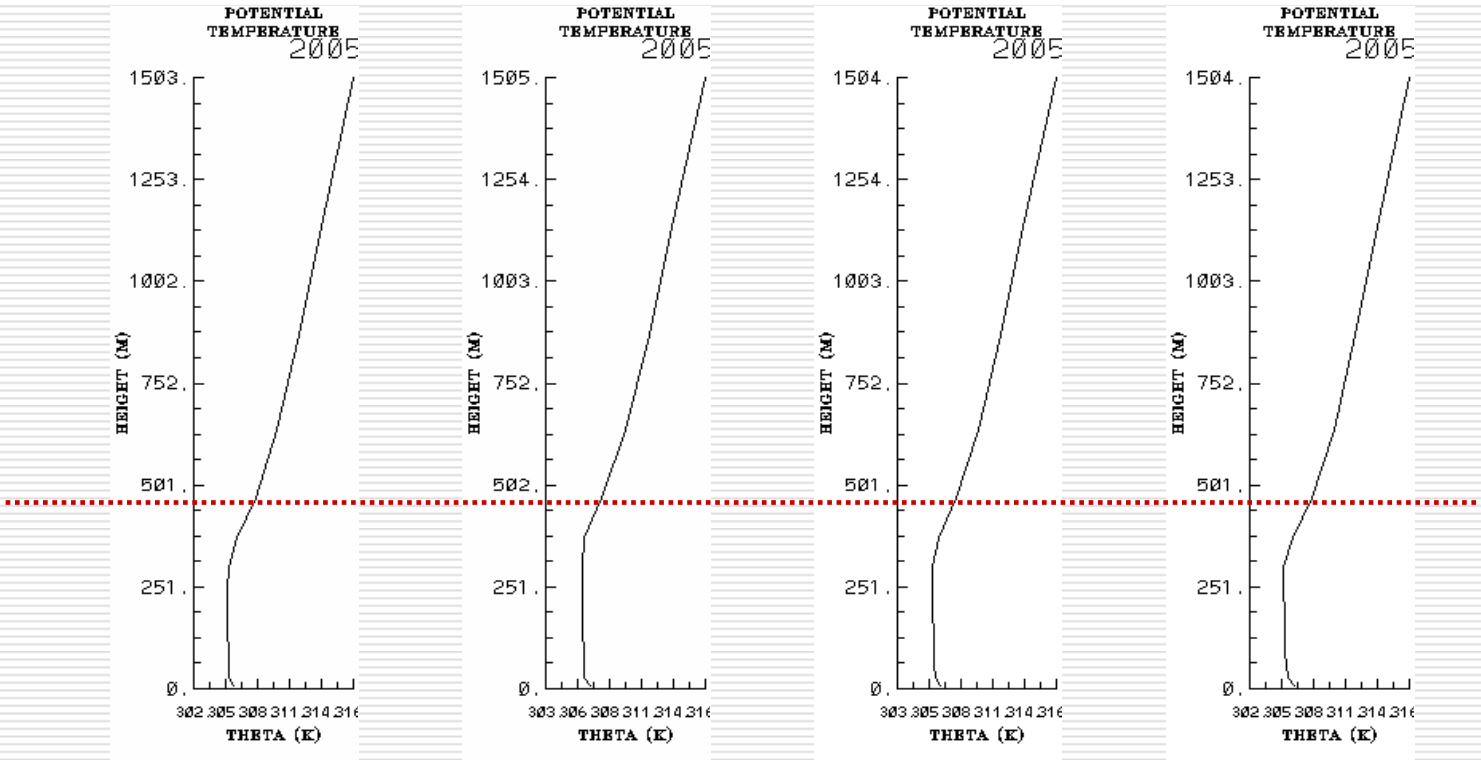




Run1 **Run21**

1000 PST Jul 16, 2005 at Ontario

Run21 **Run22** **Run23** **Run24**



R21: Mod Blackadar Default

R22: Expanded Urban, default LU params

R23: Suburban, $z_{0\ urb}$ = 1.5 m, $z_{0\ suburb}$ = 0.7 m

R24: Expanded Urban, $z_{0\ urb}$ = 1.5 m

Summary

- Updated Land Use with urban category showed improved diurnal variations of surface wind and temperature.
- Modified Blackadar run showed better agreement with measurements in terms of surface wind and temperature
- MM5 needs further verification & improvement near coastal areas.