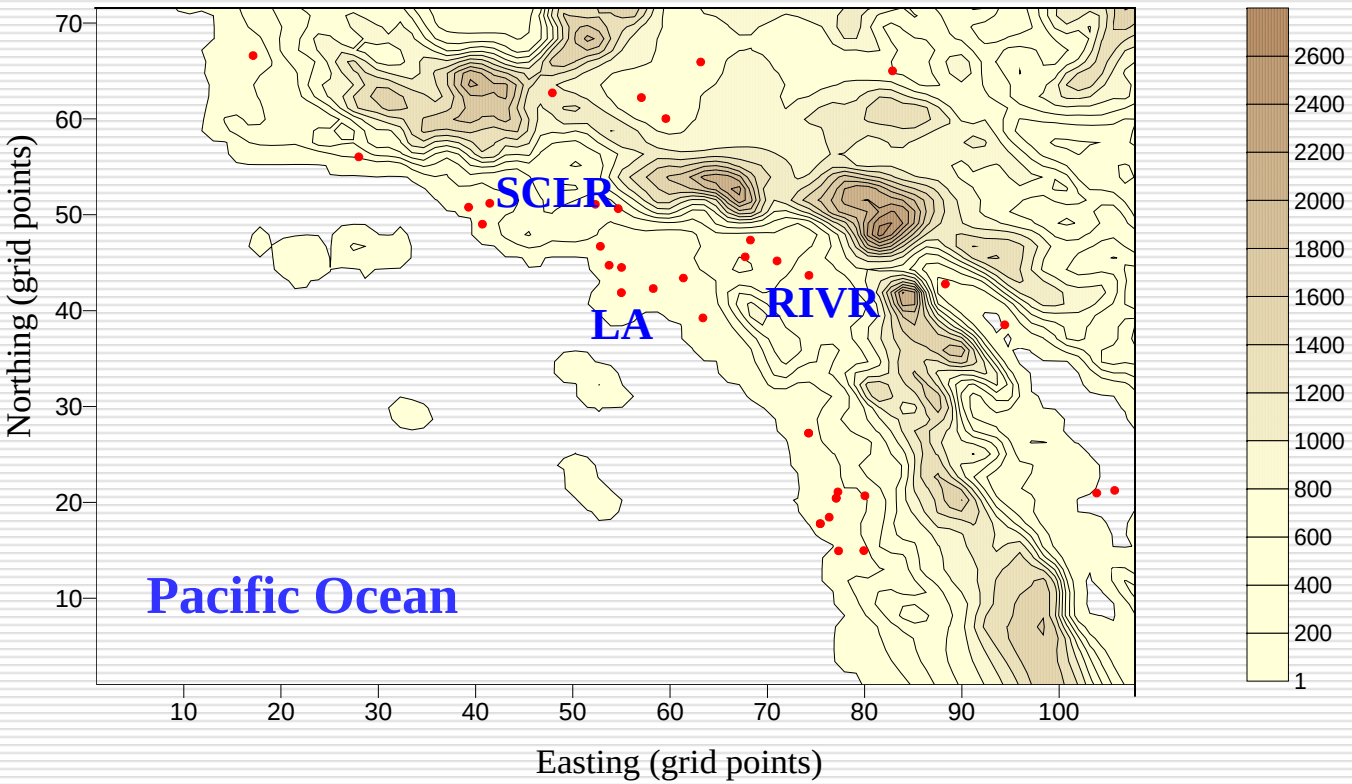
Improvement of MM5 simulation for CAMx application in Southern California

Sang-Mi Lee, Satoru Mitsutomi, and Joe Cassmassi

South Coast Air Quality Management District

Diamond Bar, CA

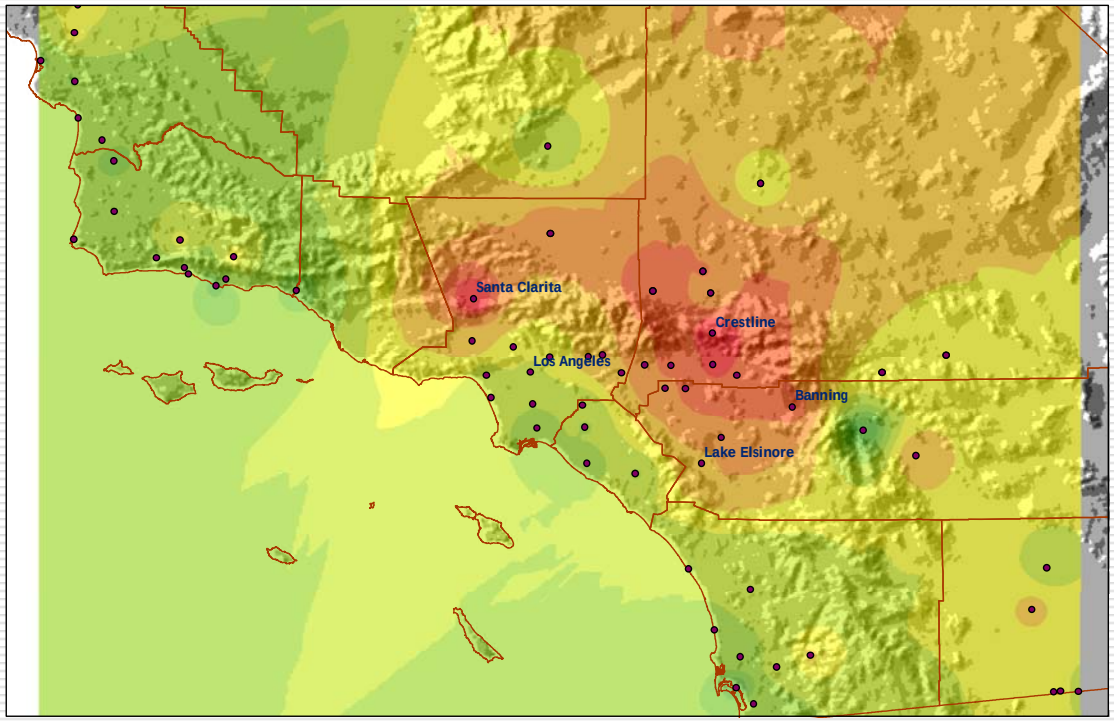
Topography in the South Coast Air Basin



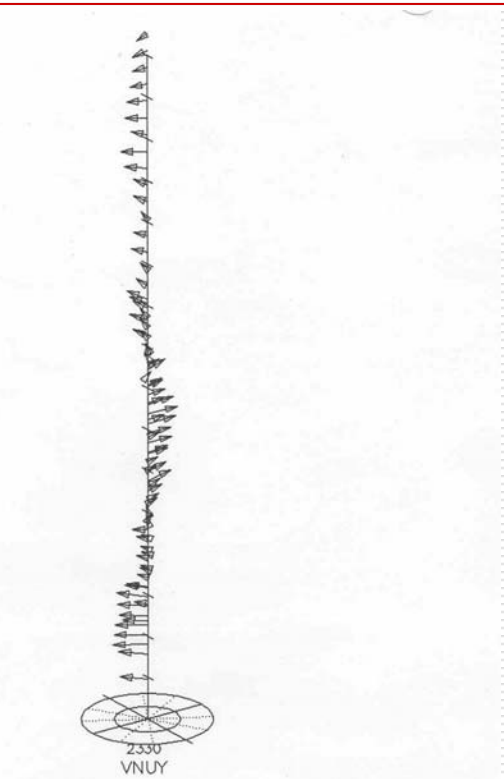
Ozone double peak pattern

Max 1-hr O_3 on July 16th, 2005: 173 ppb at SCLR

July 16



Flow Characteristics



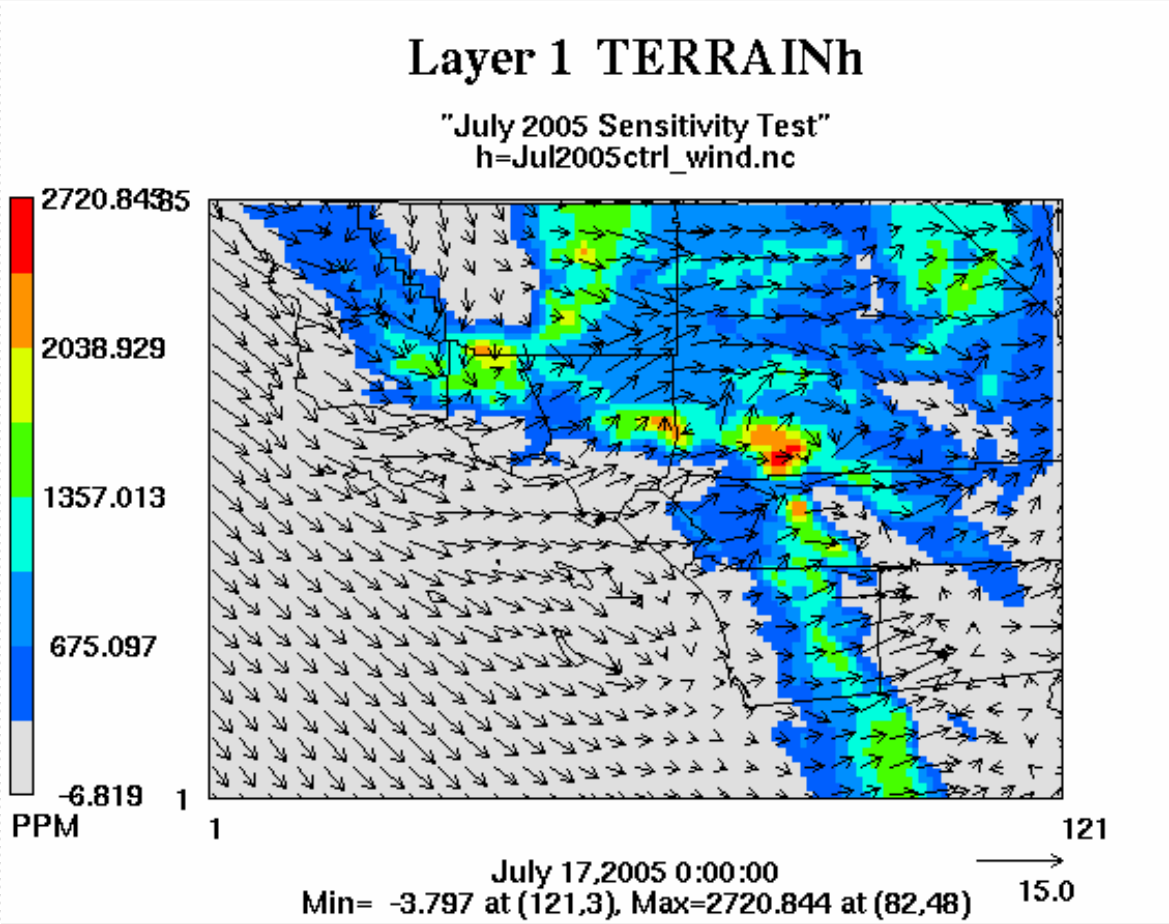
Observed upper air winds on August 6, 1997 from 2300 to 2400 GMT
Note: Arrow indicates direction toward which wind is blowing.
Group E : San Fernand Valley

The most frequent basin wind flow during July at 0100 PST (A Climatological Air Quality Profile, California South Coast Air Basin)

MM5 Default Configuration

- First guess field: Eta 212 grid analysis output
- Three domains of which grid distances are 45, 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.

Typical MM5 simulation results



Proposed Methodology

Increase surface drag via z_0

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

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

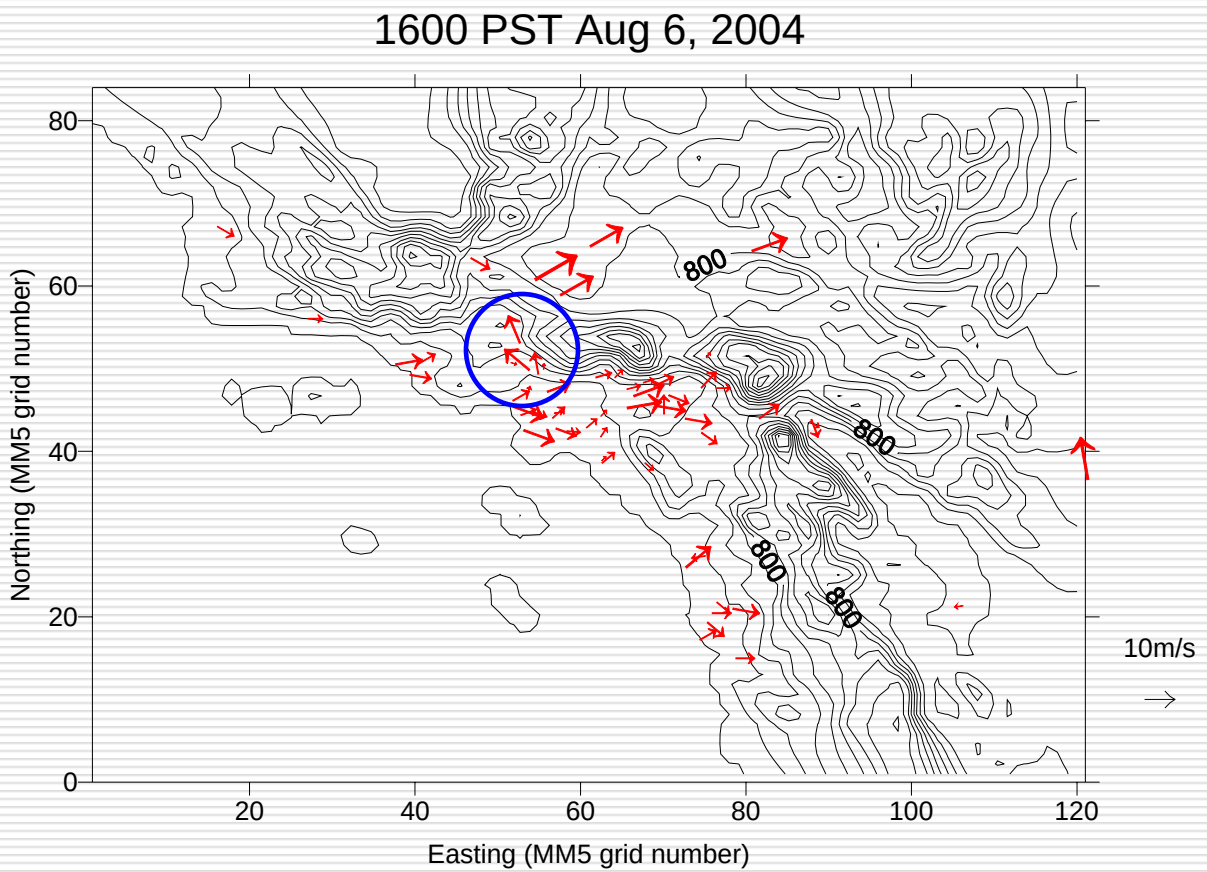
  - For the episode cases, z_0 ~< 0.03 cm
  - Urban = 0.5 m
- Modifications
  - water: z_0= 0.1 cm
  - urban =1.5 m
  - The rest of LU categories: increased by two times

Increase soil layer moisture availability

- Other studies:
  - Chen et al. 2001: additional term to account for water usage in urban area
  - TAPM simulation for LA area indicated the need to increase soil moisture content (paper in preparation).

- Modifications
  - Urban: increased by three times
  - The rest LU categories: increased by two times

Nudging observational wind field



1-way Nesting

Default options

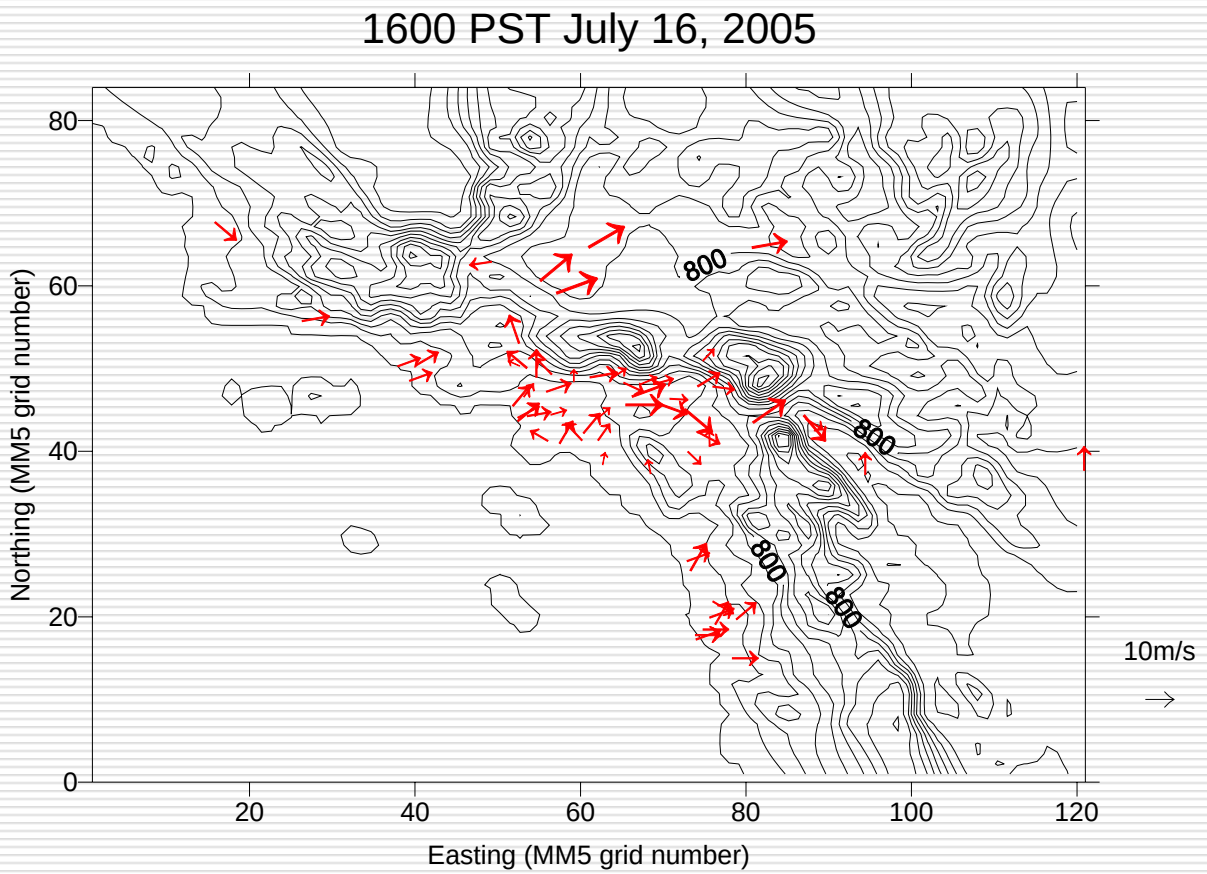
- Two-way nesting
- 3-D & Surface analysis nudging
- no modifications on surface characteristics

Modified Runs

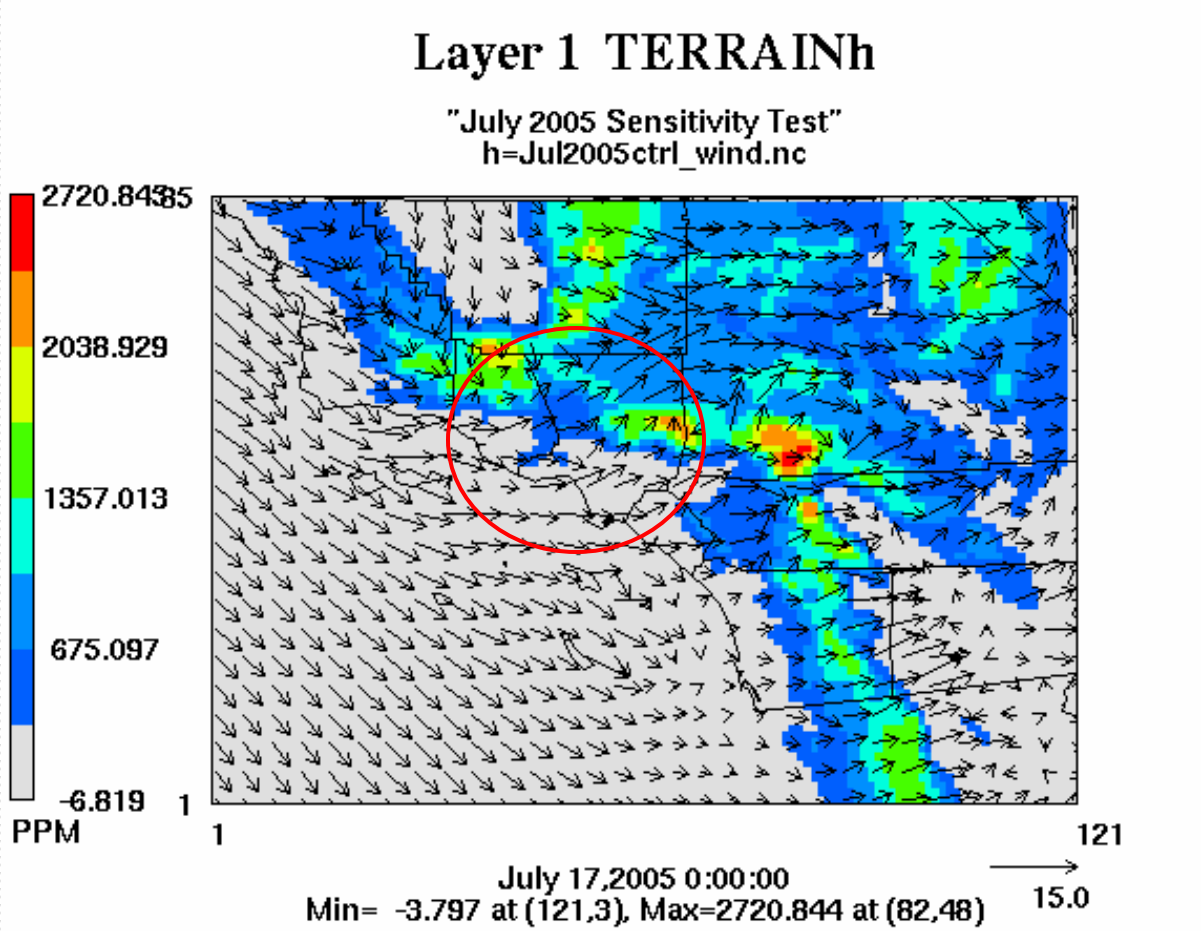
- One-way nesting
- surface observational nudging
- modified surface characteristics

Modeling Results

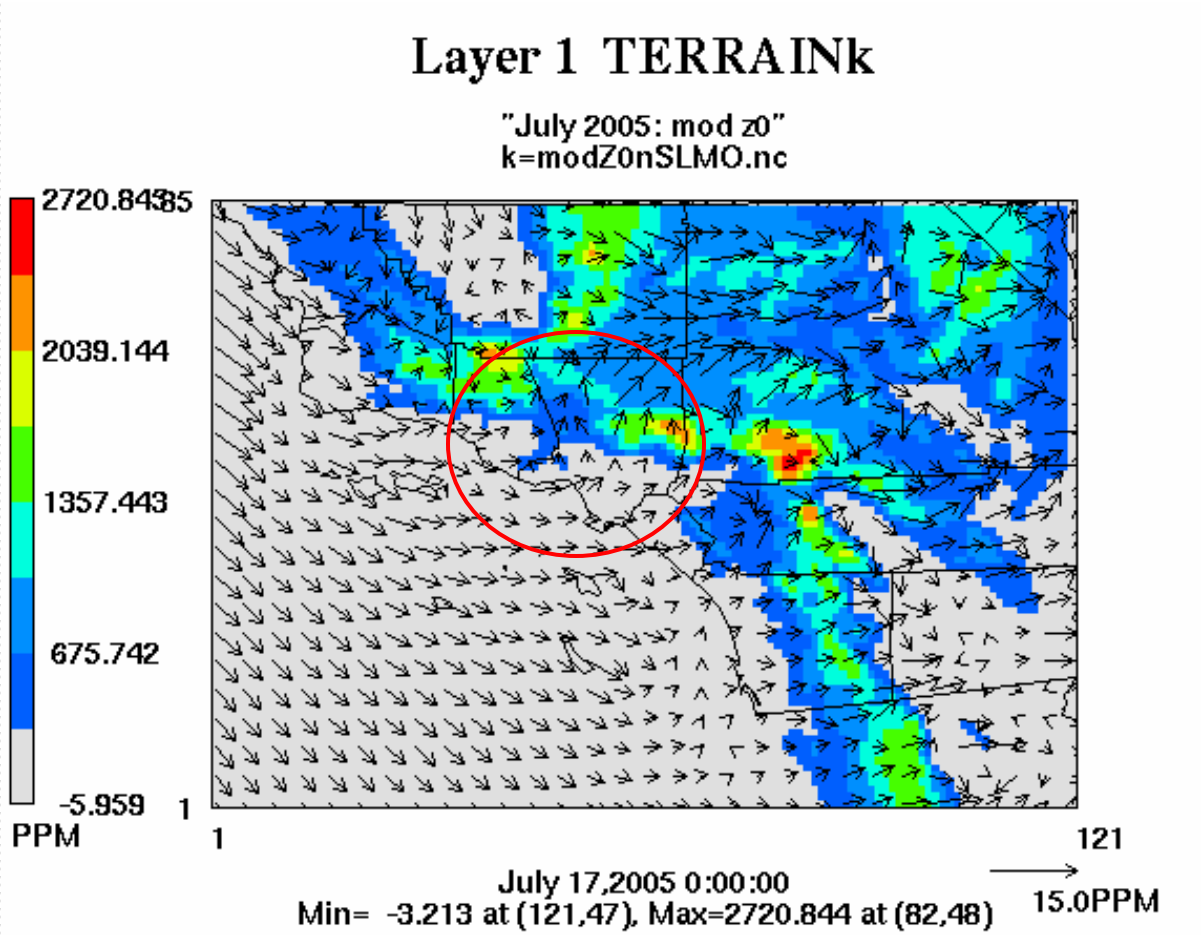
Observed Surface Wind Field



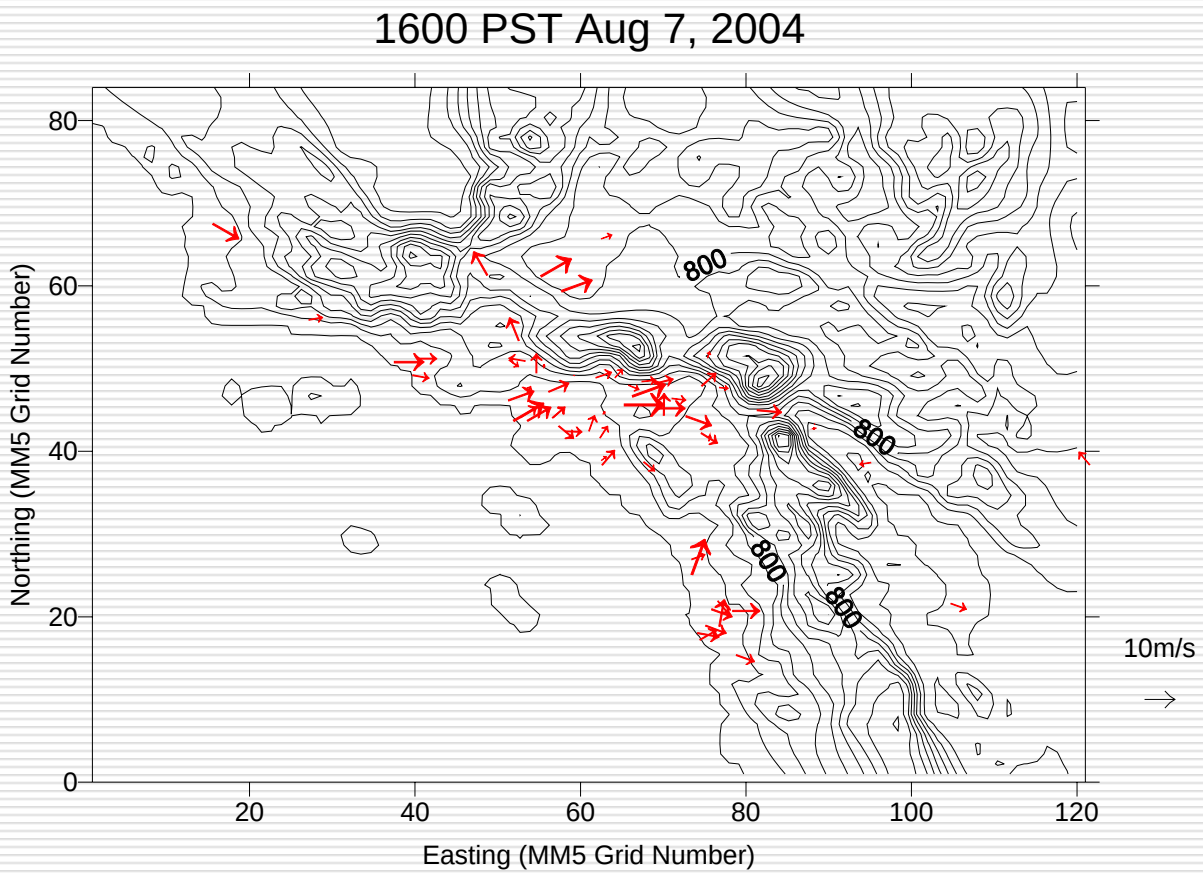
MM5 Default Run



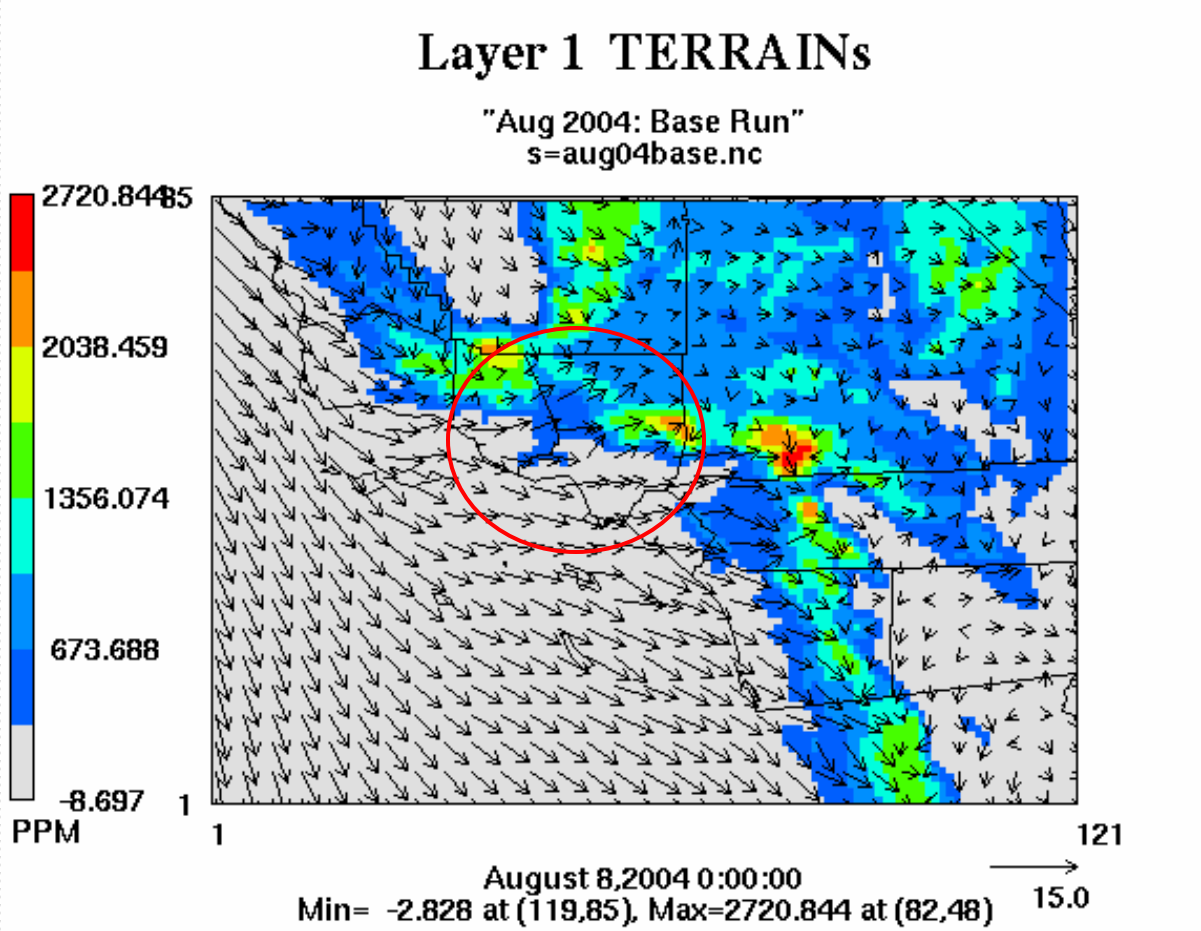
MM5 Modified Run



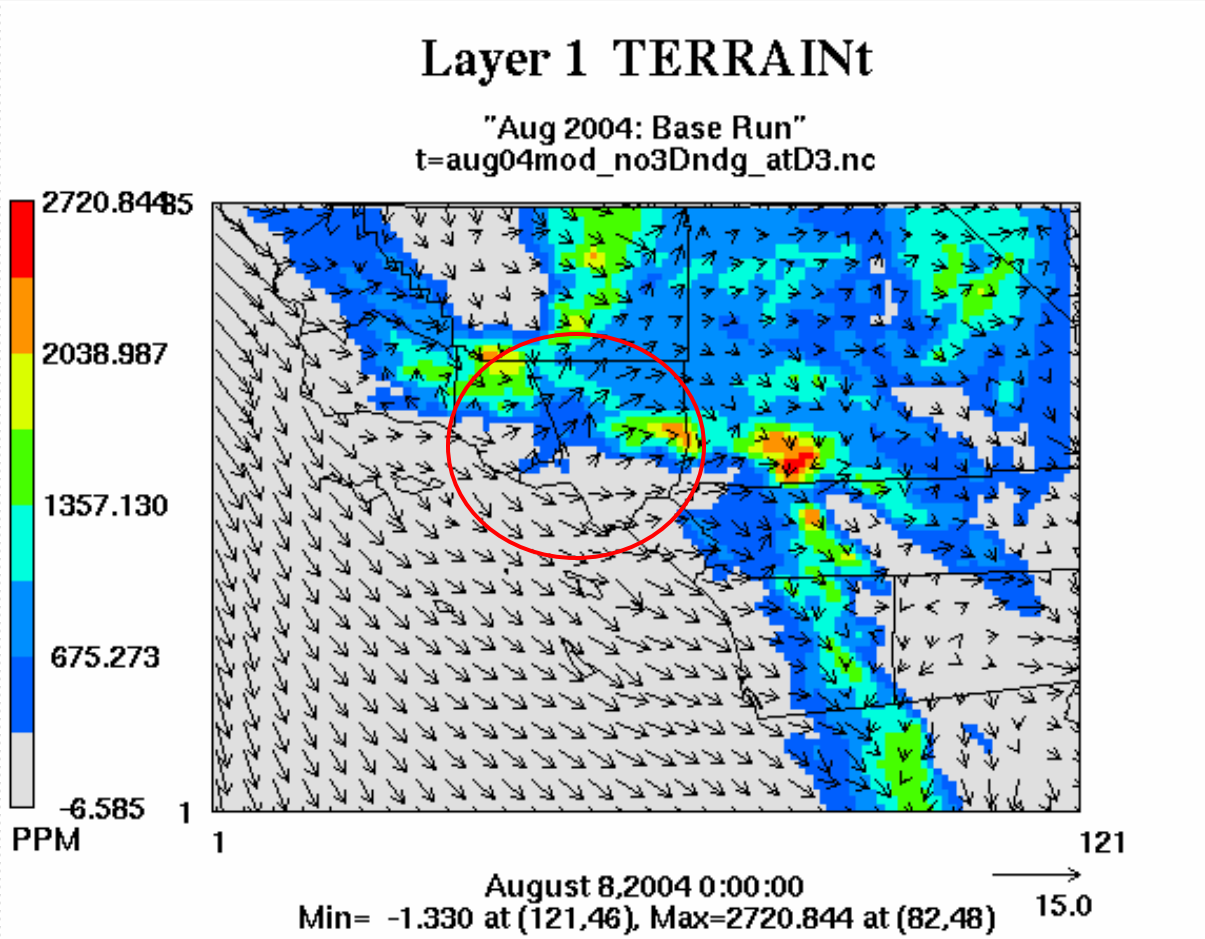
Observed Surface Wind Field



MM5 Default Run

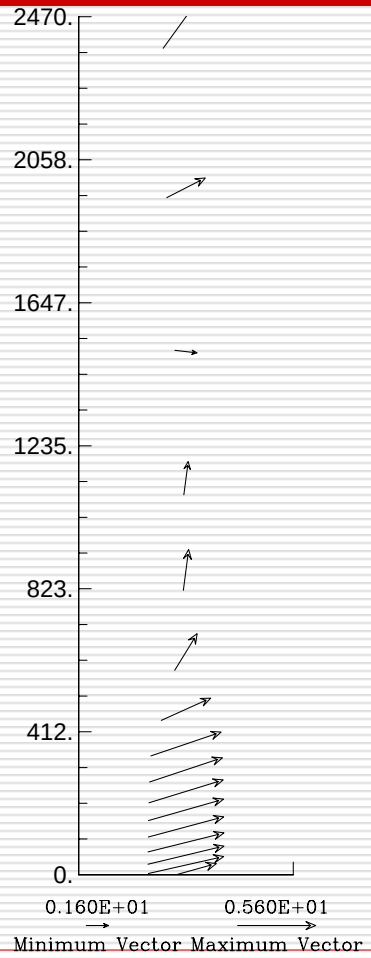


MM5 Modified Run

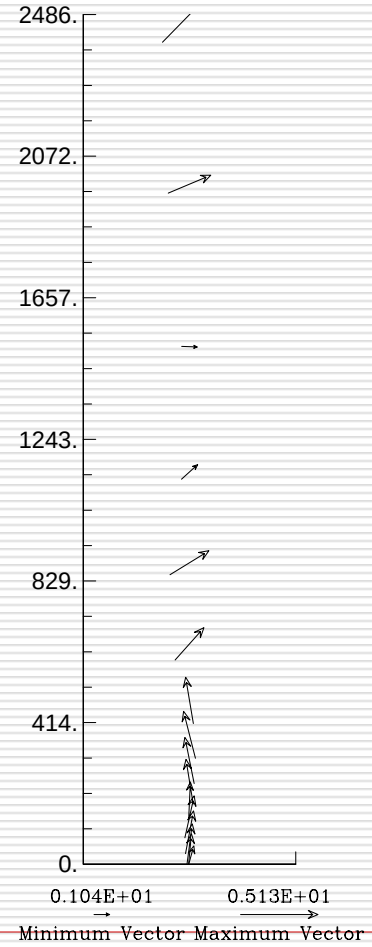


MM5 simulated Wind Profiles:

0000 UTC July 17, 2005



Base



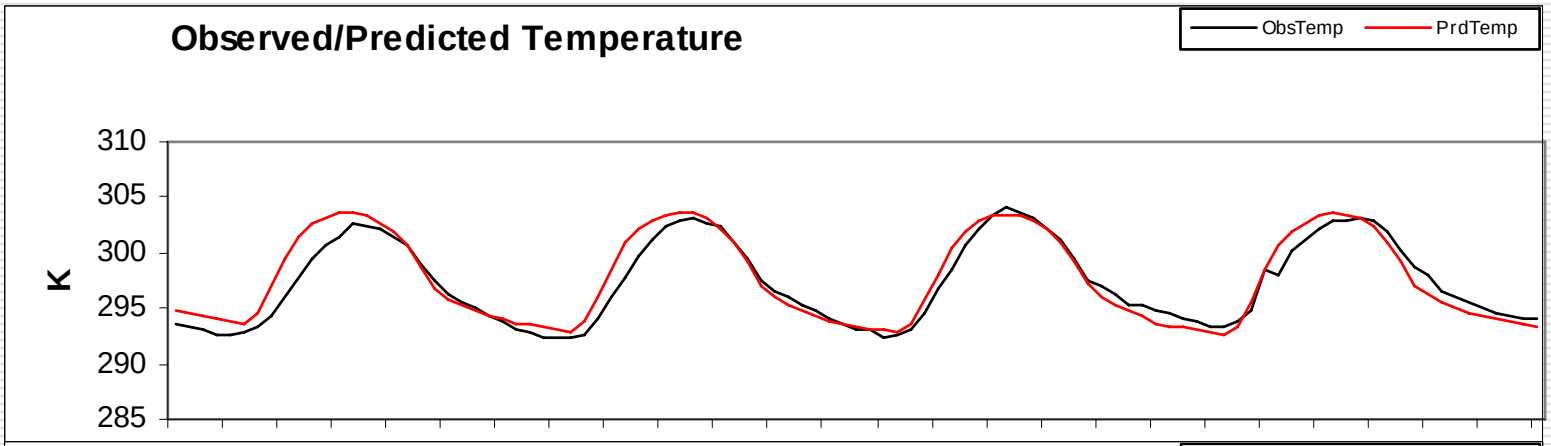
N

4

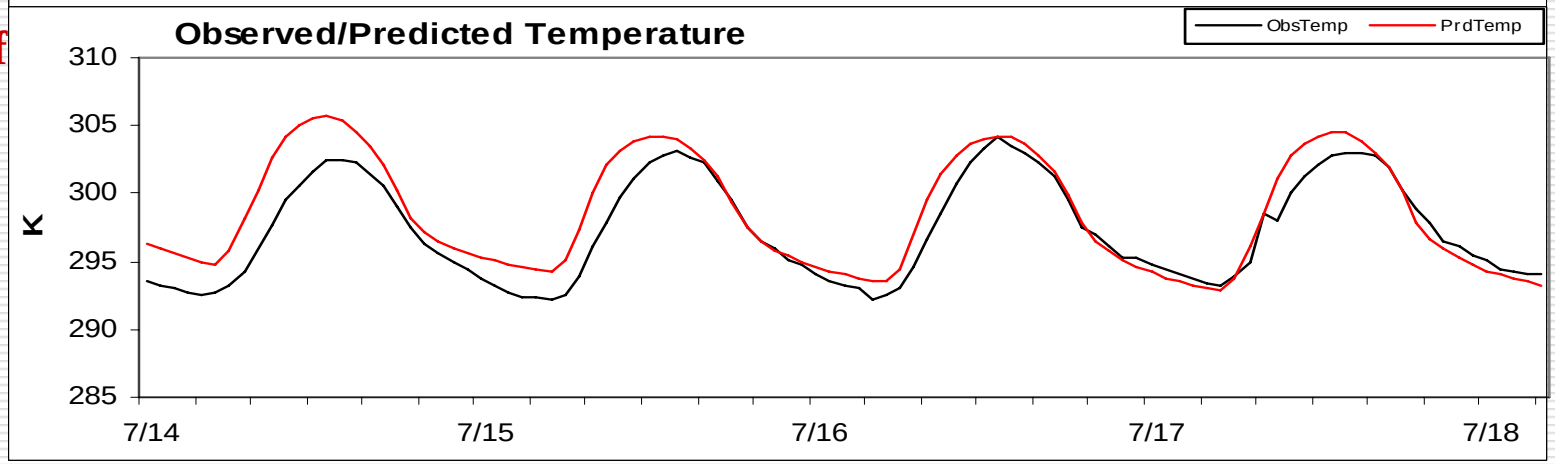
Modified

Basin-wide Avg T:
MM5 default vs. z_0 only modification

Default

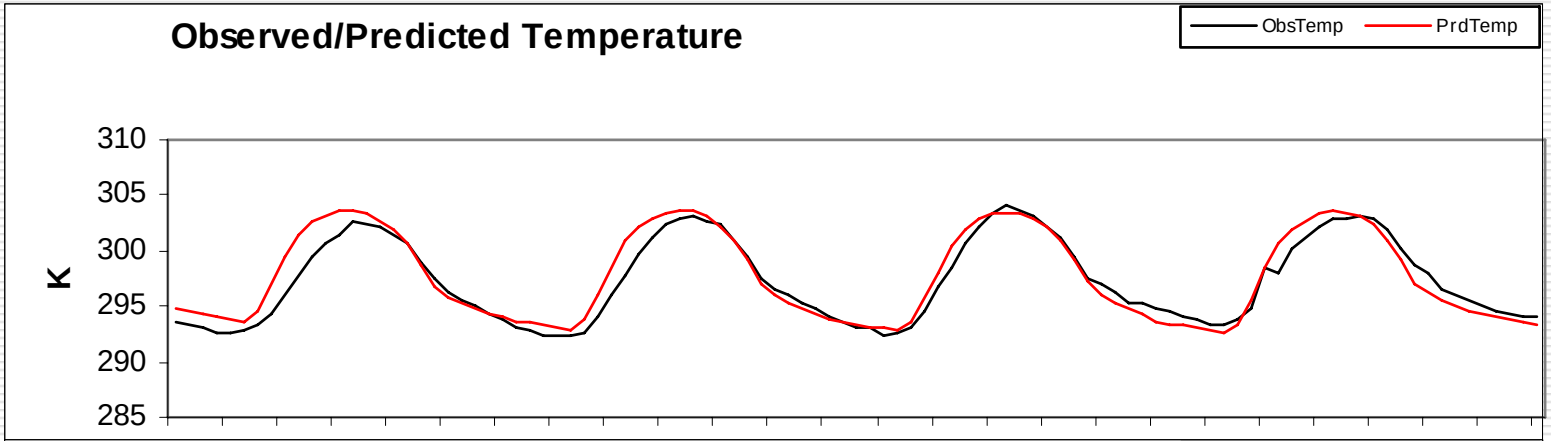


Z_0 Modif

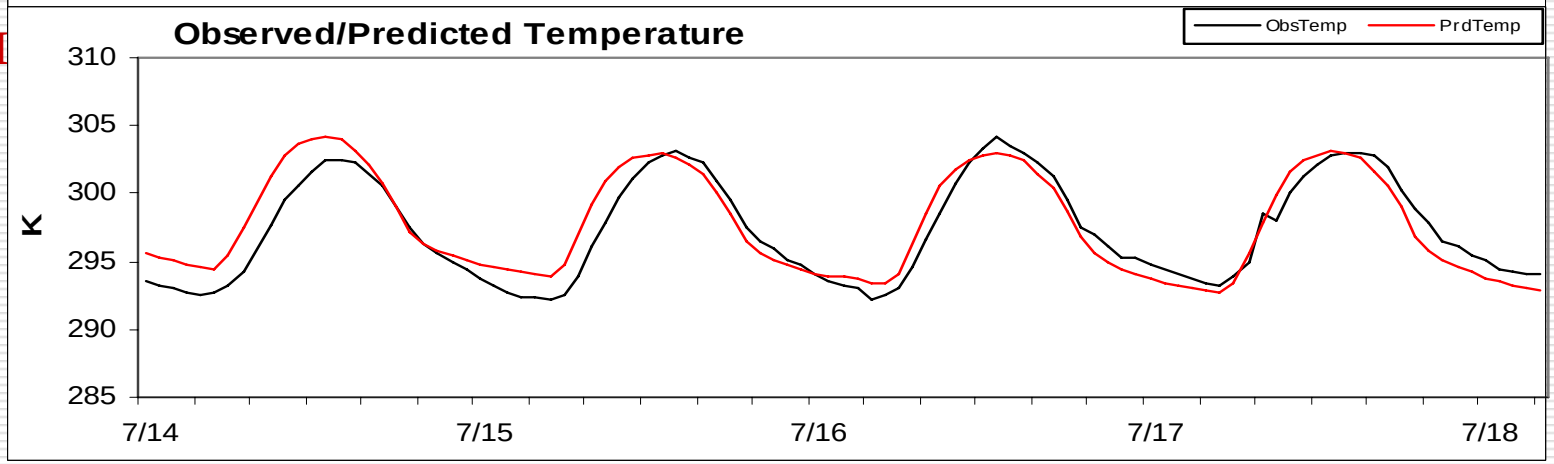


Basin-wide Averaged T: MM5 Modifed

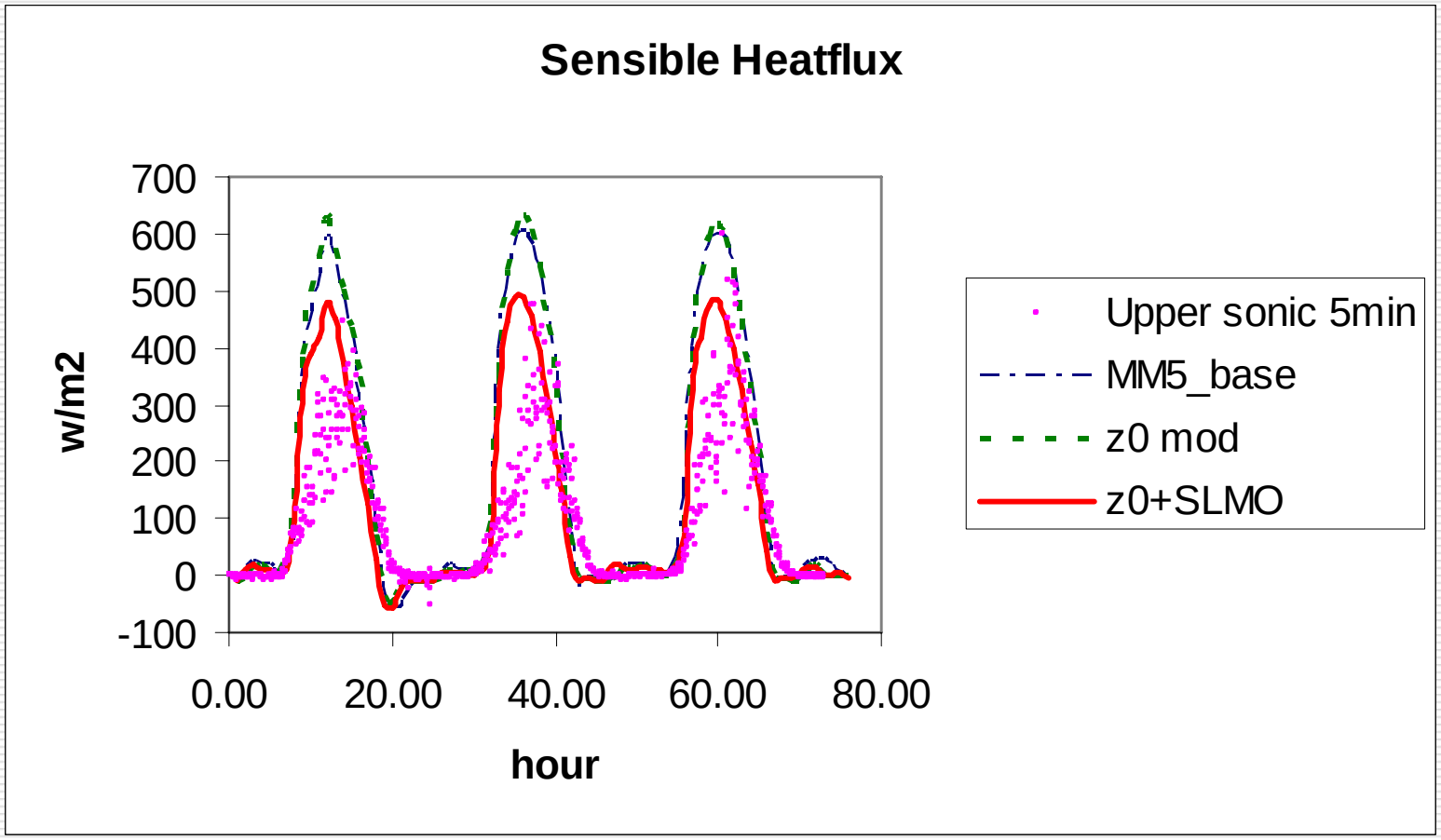
Default



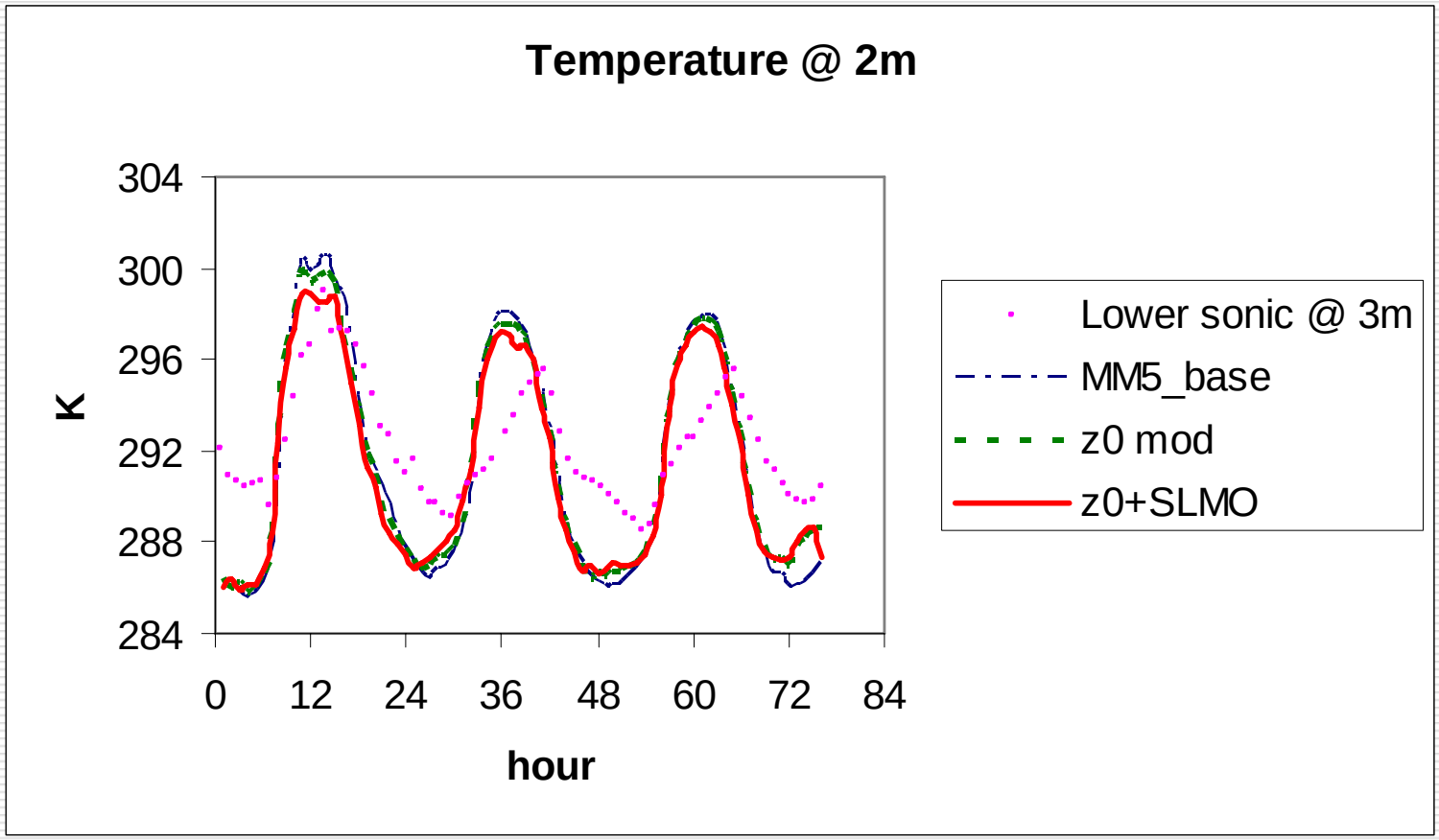
Z_0 + SLM Modified



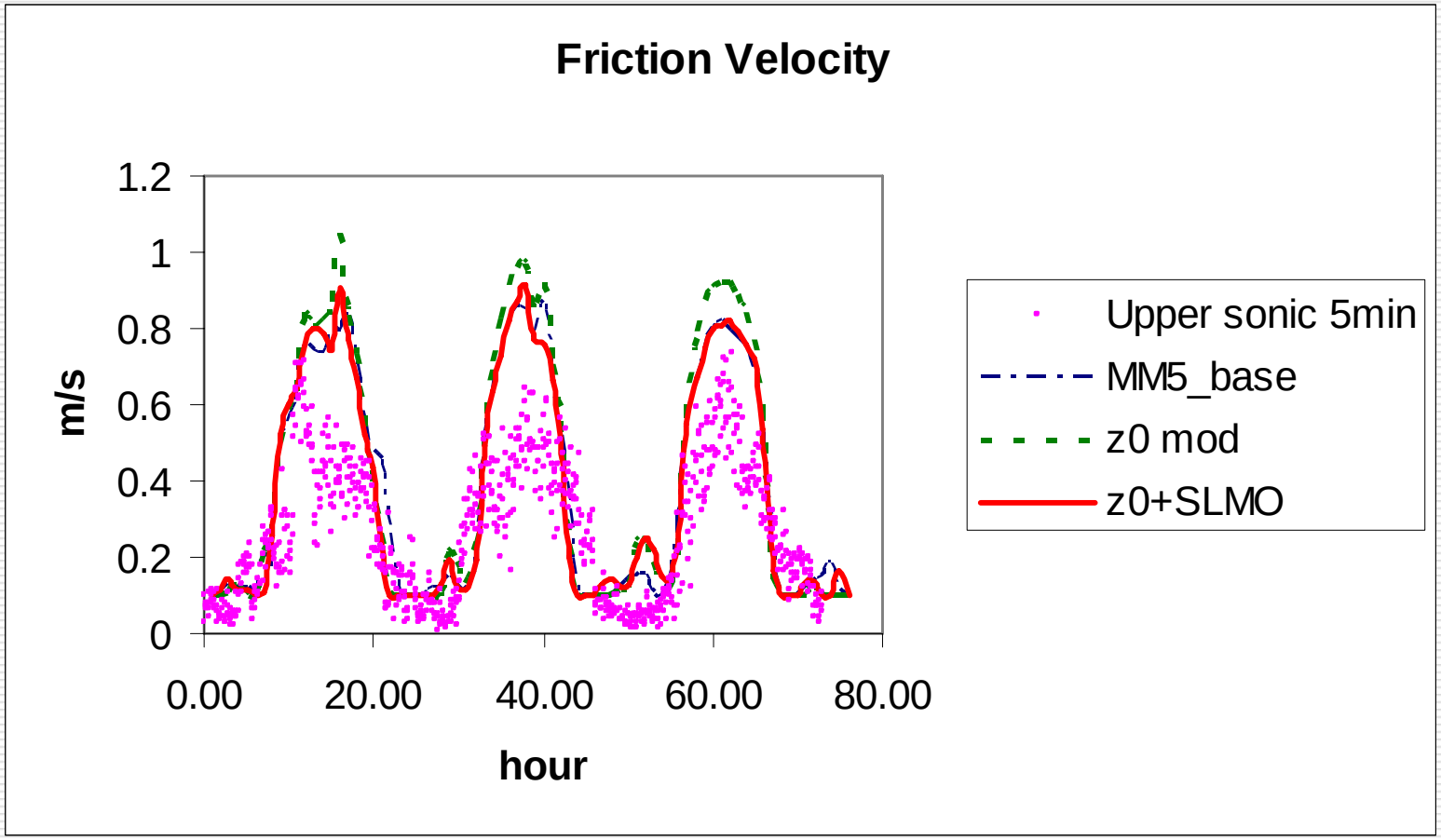
Turbulence Heat Flux



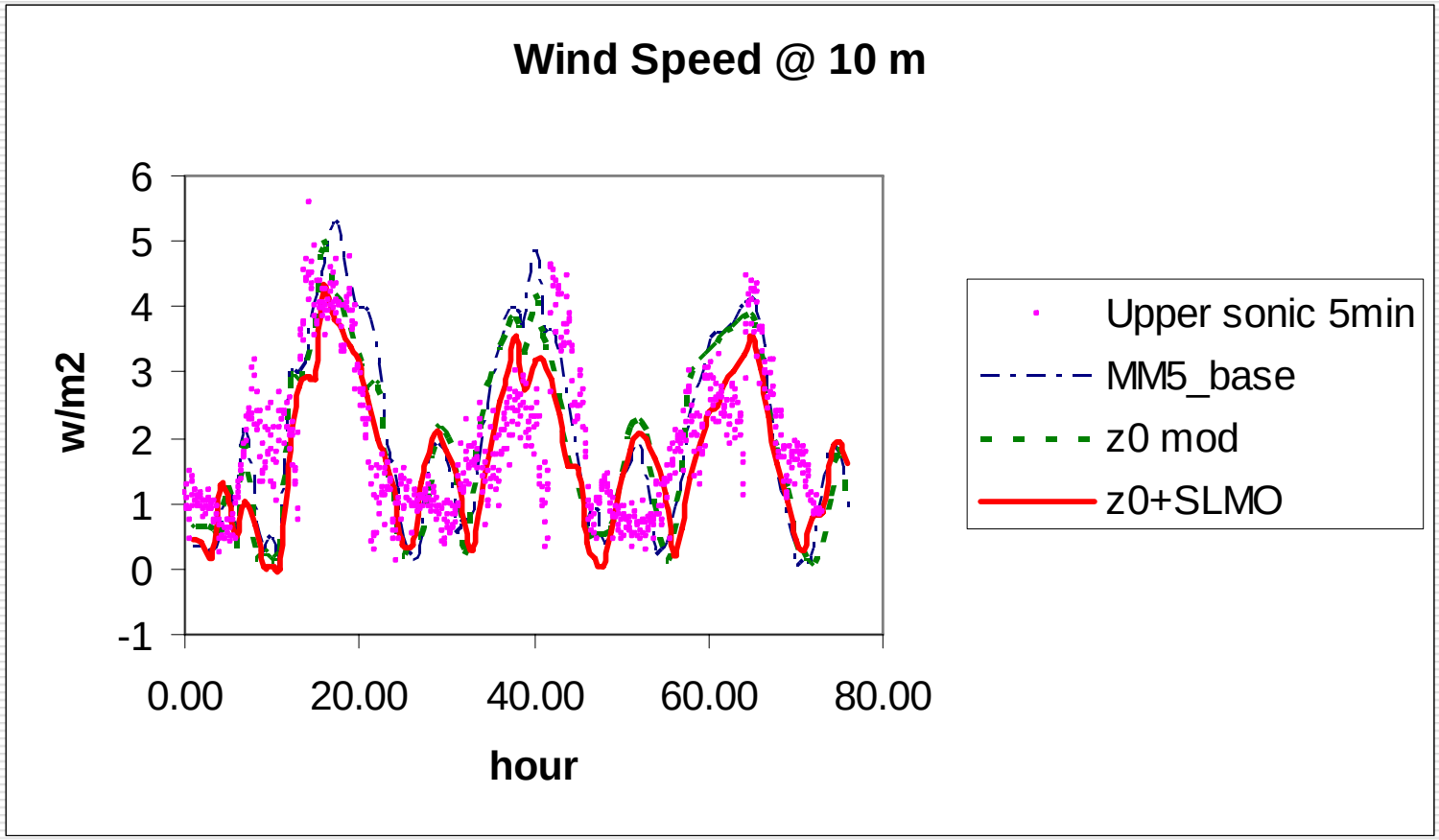
Mean Temperature



Turbulent Momentum Flux



Mean Wind Speed



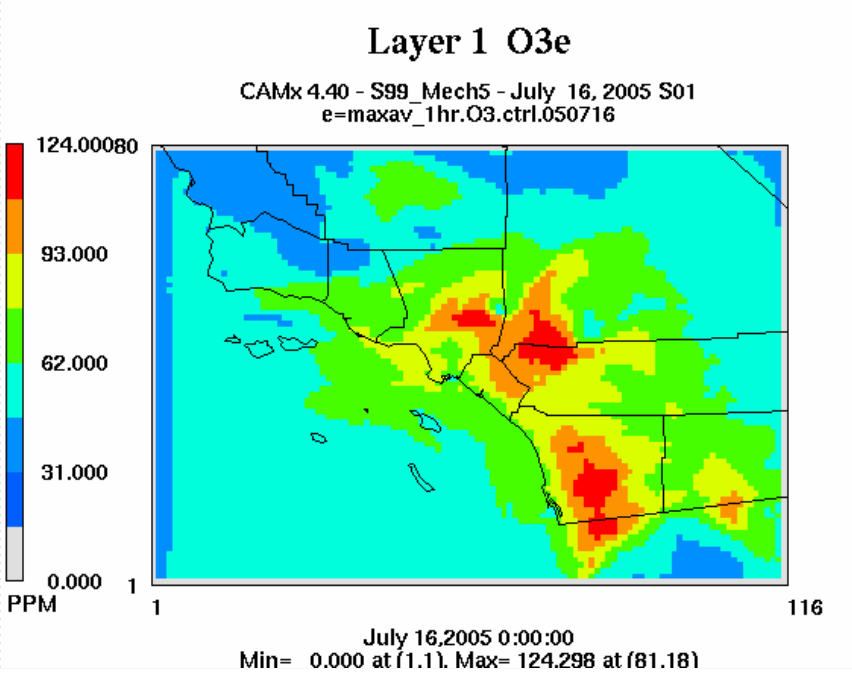
Air Quality Simulations

CAMx Configuration

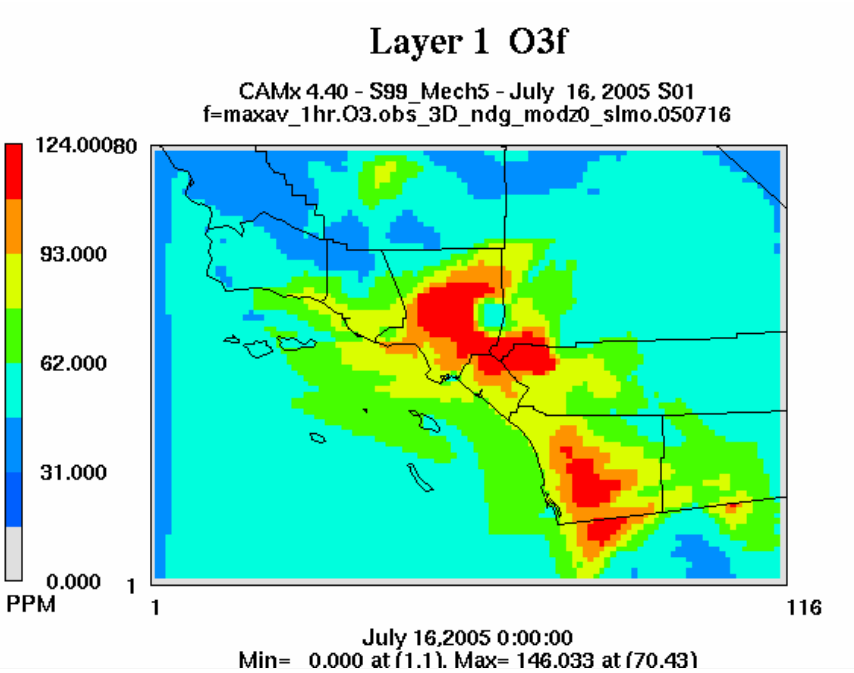
- CAMx/SAPRC99 version 4.4
- Number of grids: 116 X 80
- Horizontal grid spacing of 5 km
- Vertical layer collapsing: from 30 to 16 layers
  - The first layer approximately at 35 m agl
  - The domain top at 5000 m
- Vertical diffusivity: OB70 w/ Kv patch
- Minimum diffusivity coefficient = 1.0 m^2/s

MM5 Ctrl vs. MM5 Mod: Jul 2005 Case

Control Run

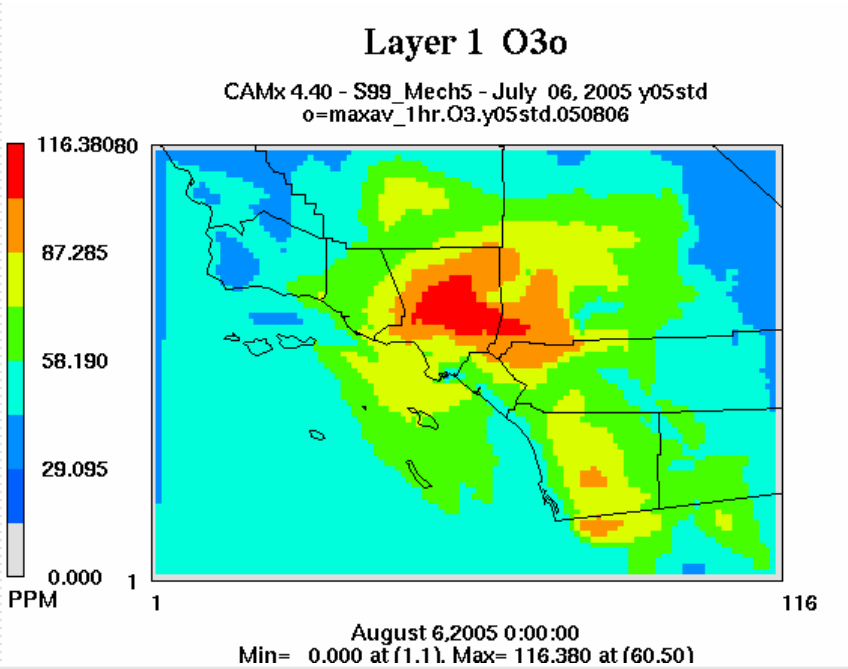


Modified Run

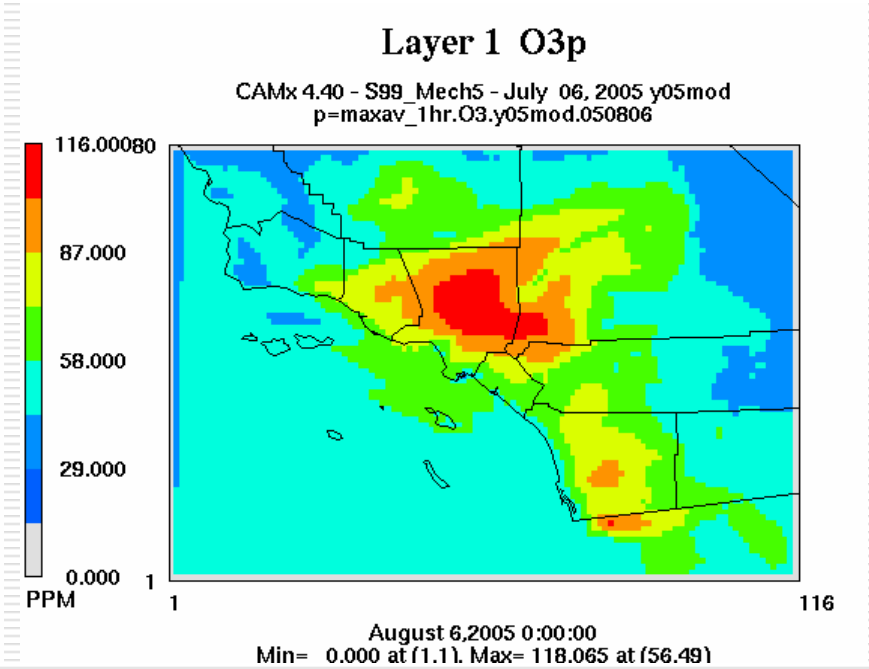


MM5 Ctrl vs. MM5 Mod: Aug 2005 Case

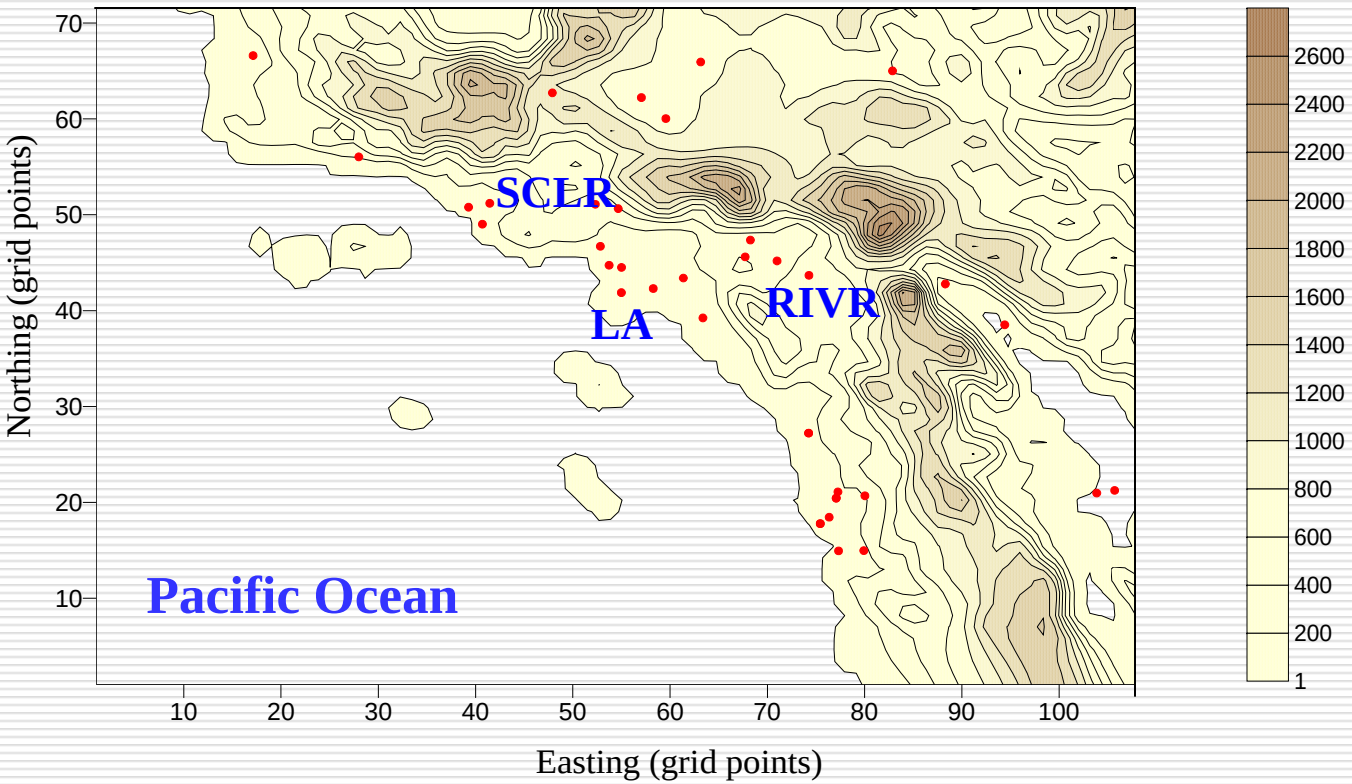
Control Run



Modified Run

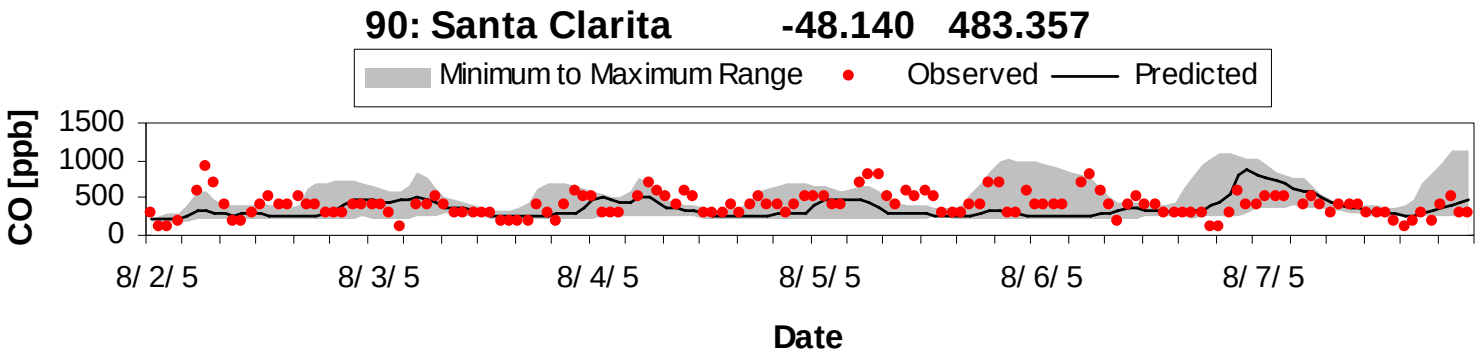


Topography in the South Coast Air Basin

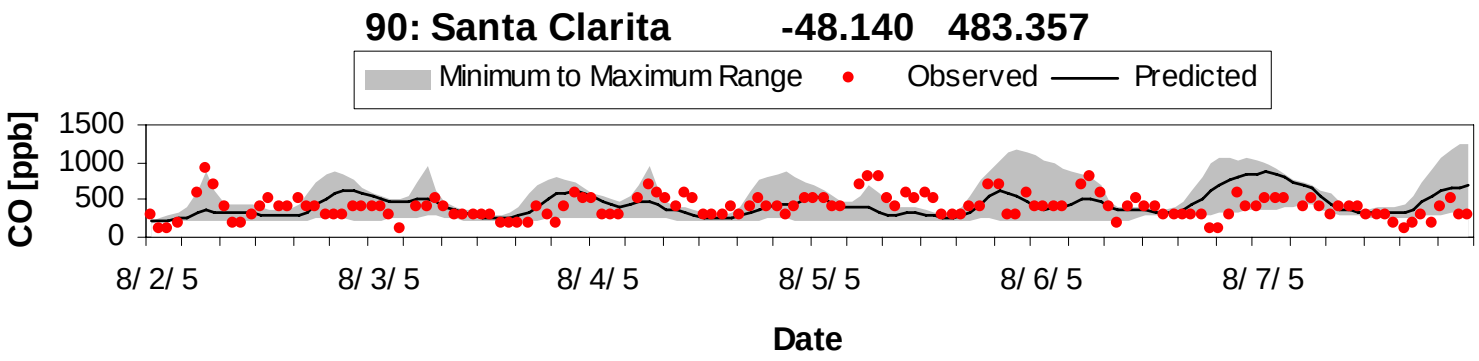


CO Timeseries: Santa Clarita Area

Default

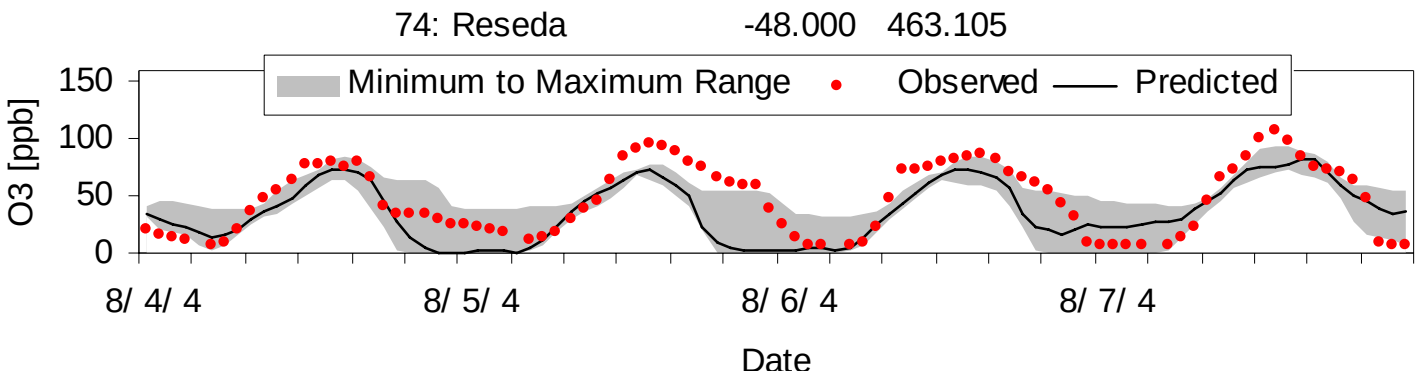


Modified

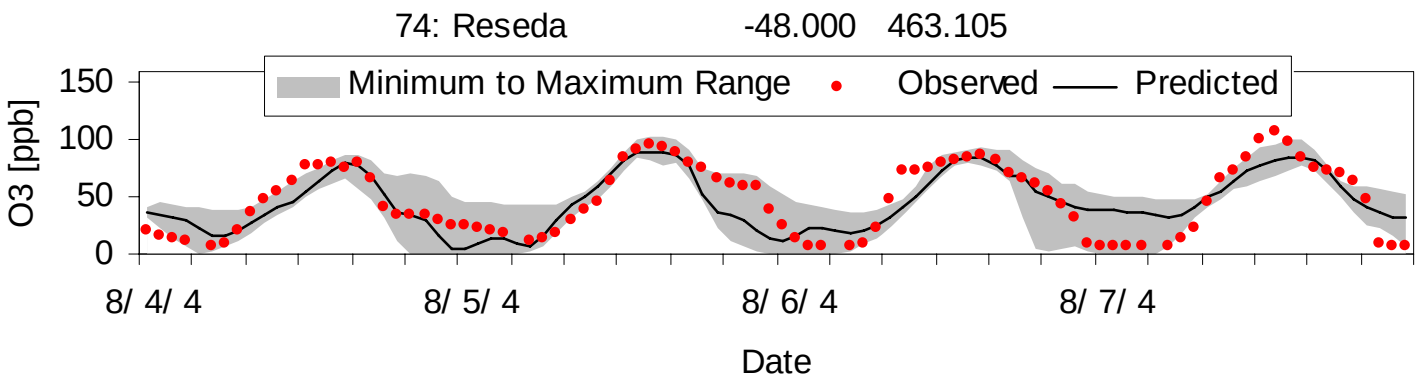


Ozone Timeseries: Santa Clarita Area

Default

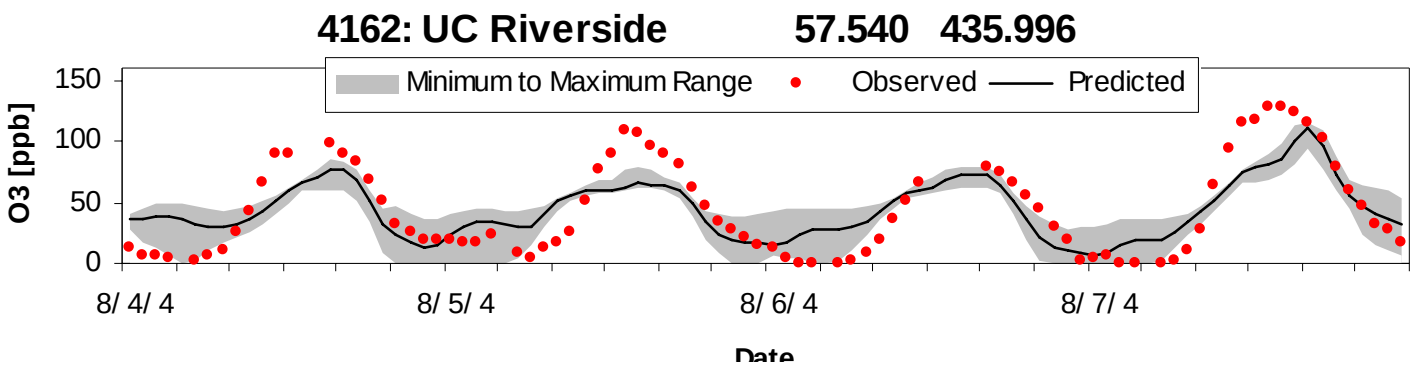


Modified

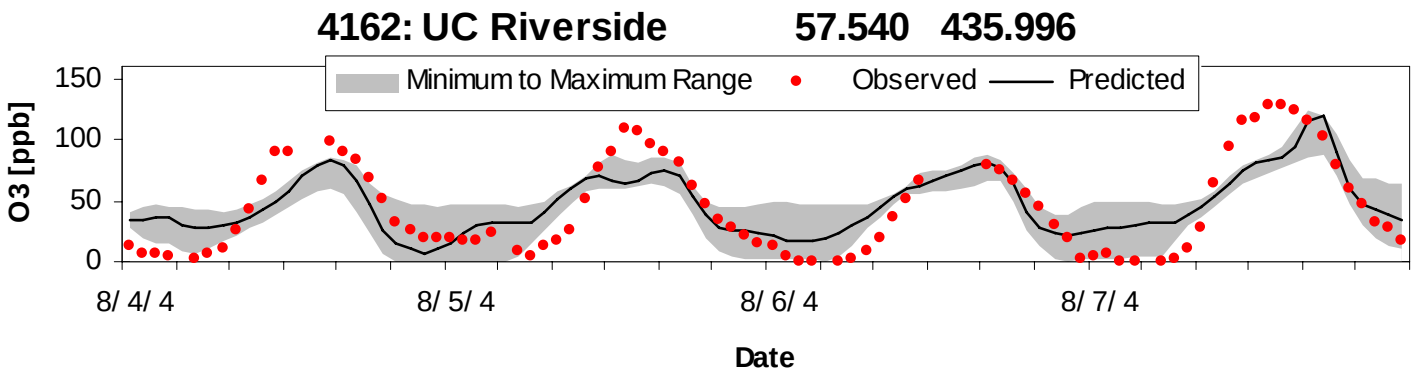


Ozone Timeseries: Riverside Area

Default



Modified



Summary

- Preliminary study showed that the proposed methodology can be effective to simulate flow turning toward Santa Clarita area.
- Comprehensive study on surface and land use characteristics will be helpful for further improvements.