

Performance of a Meteorological Forecast System for Two High-Ozone Episodes in the Los Angeles Basin

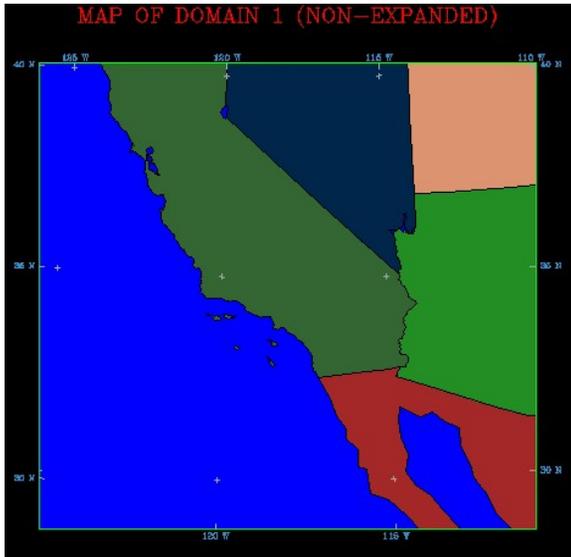
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Ann Mazuk^{*}

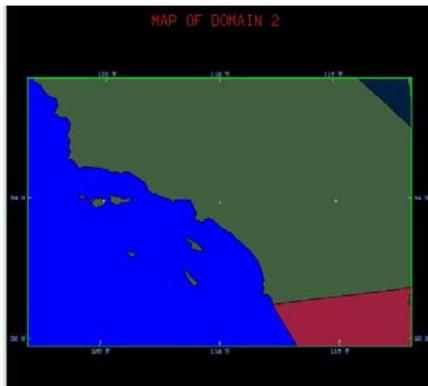
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- Original Intent: Generate meteorological and air quality model forecasts for Southern California during the summer of 2005 for comparison to the EPA-NOAA National Air Quality 5X developmental forecasts
- Current Activity: SCAQMD and Aerospace are jointly testing Comprehensive Air Quality Model with Extensions (CAMx) with MM5/3DVar and WRF meteorological platforms to evaluate the system as an ozone forecasting tool for Southern California
- Objectives of the analysis include:
 - Assess the fit of the meteorological fields for various configurations of MM5 and other Met models (NAM and WRF) for two high ozone episodes (14-19 Jul & 24-29 Aug 2005)
 - Identify critical areas of MM5/3DVAR model performance
 - Assess the accuracy of ozone prediction



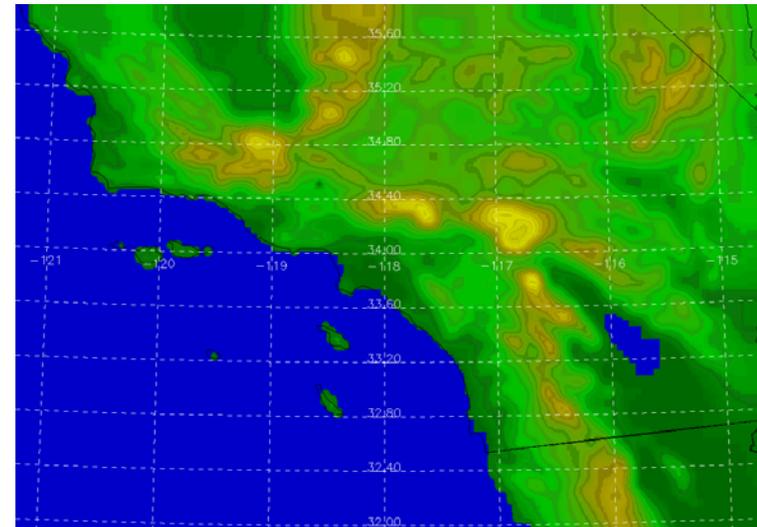
Outer Domain 1 ($\Delta x = 15$ km)



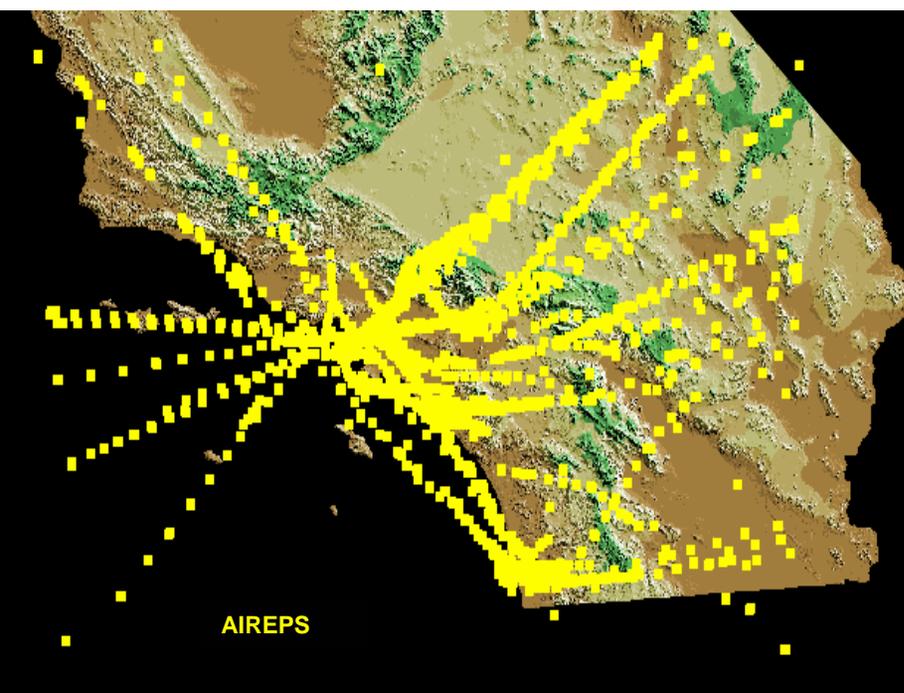
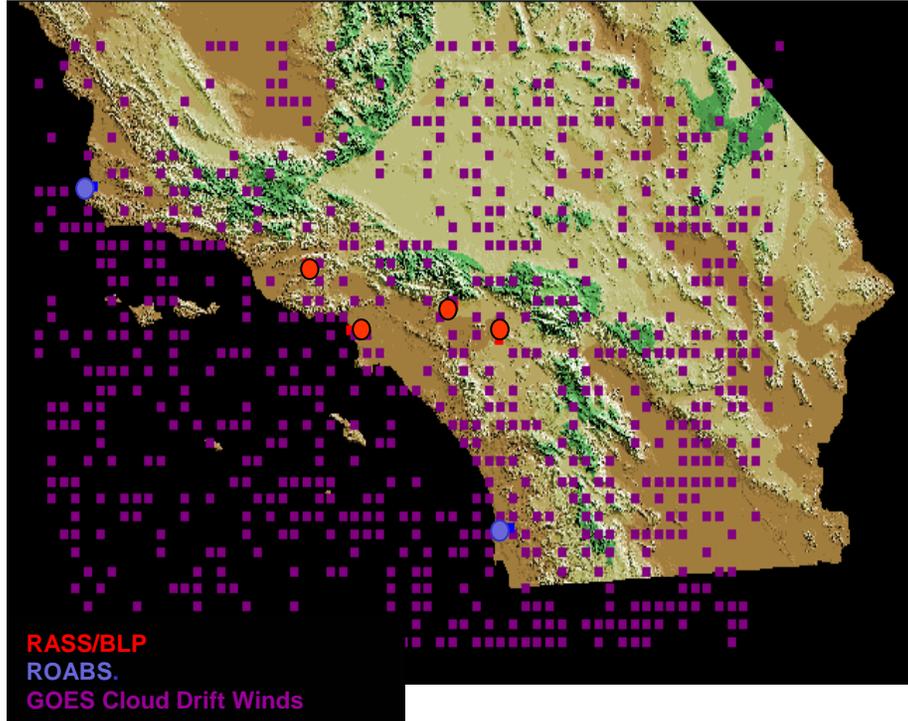
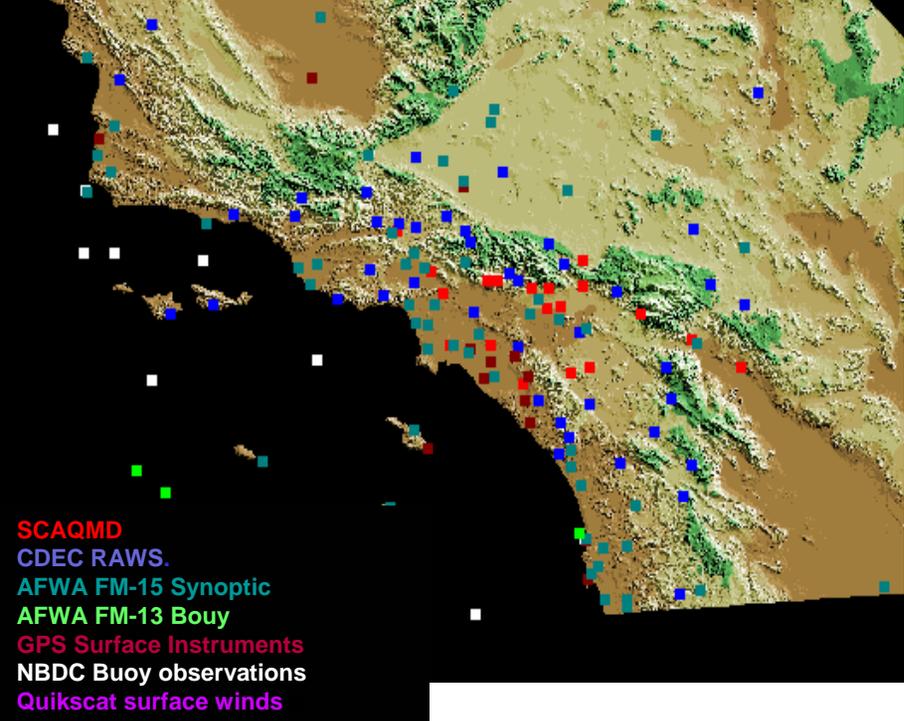
Inner Domain 2 ($\Delta x = 5$ km)

MM5 3-Dimensional Variational Analysis System (3DVAR)

- A wide variety of local and remotely sensed observations are assimilated
- Data assimilation cycle employed for both outer and inner domain
- Background errors computed for each domain

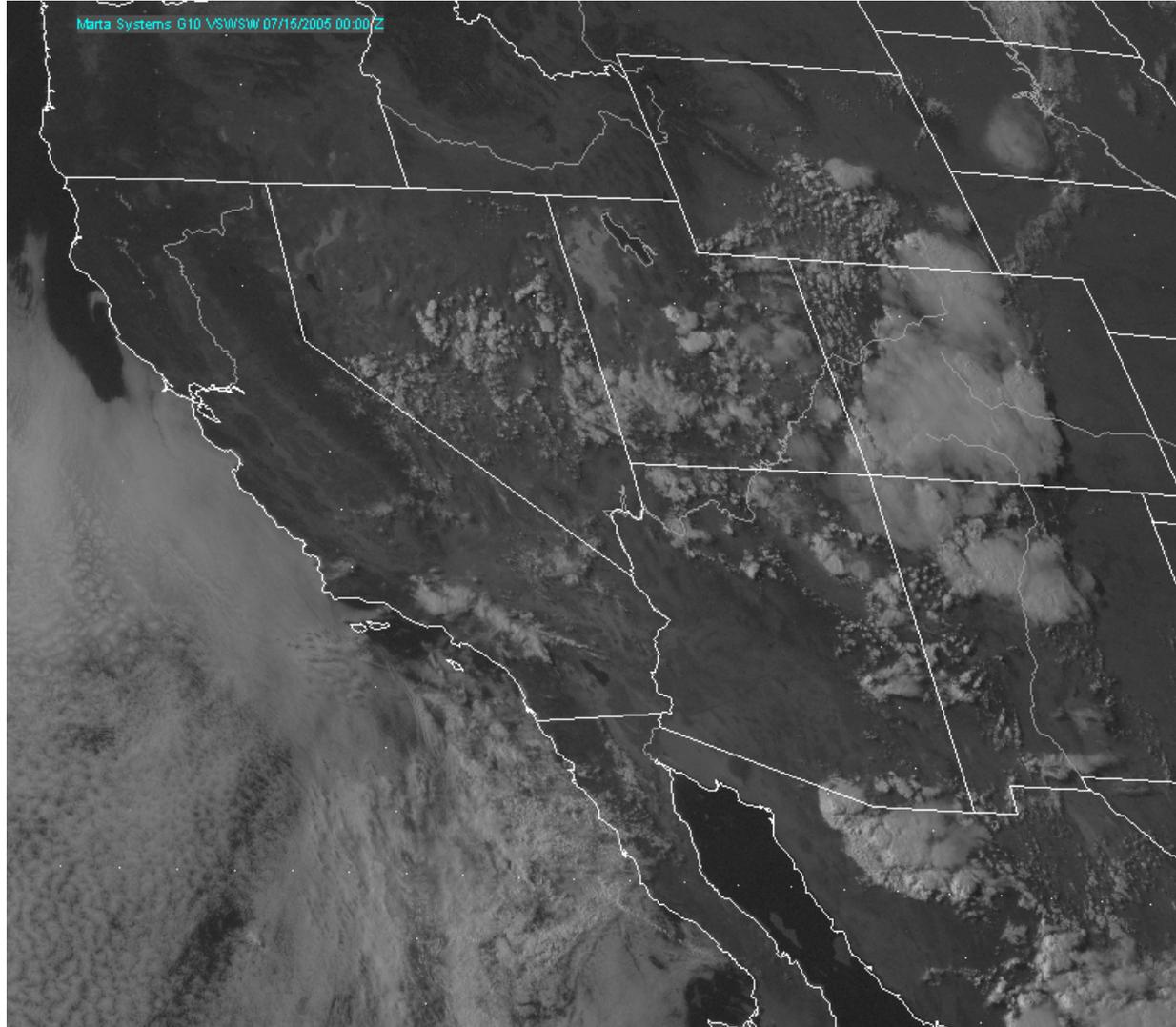


Terrain of Inner Domain



- Examples of observation types their distribution
- All observations types are assimilated and most are used for in-house verification
- SCAQMD surface observations are used by the MetStat verification system

Large Scale Conditions Present During High-Ozone Episodes

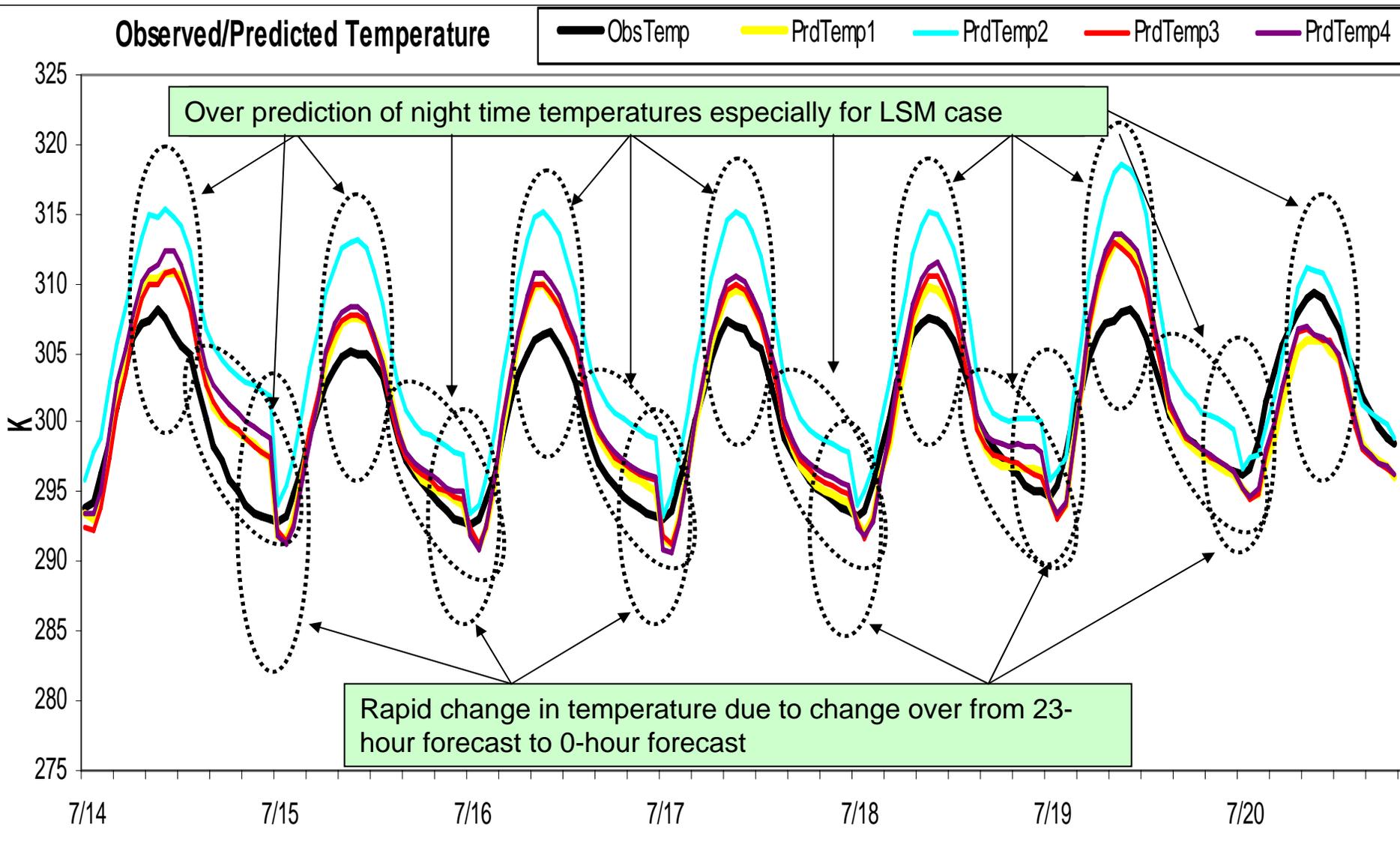


- High pressure is the dominant feature for both periods with its associated subsidence, temperature inversions, light winds, marine stratus and warm inland temperatures
- Coastal stratus in the LA basin is prevalent during the first half the the Jul period
- Low-level flow is generally onshore

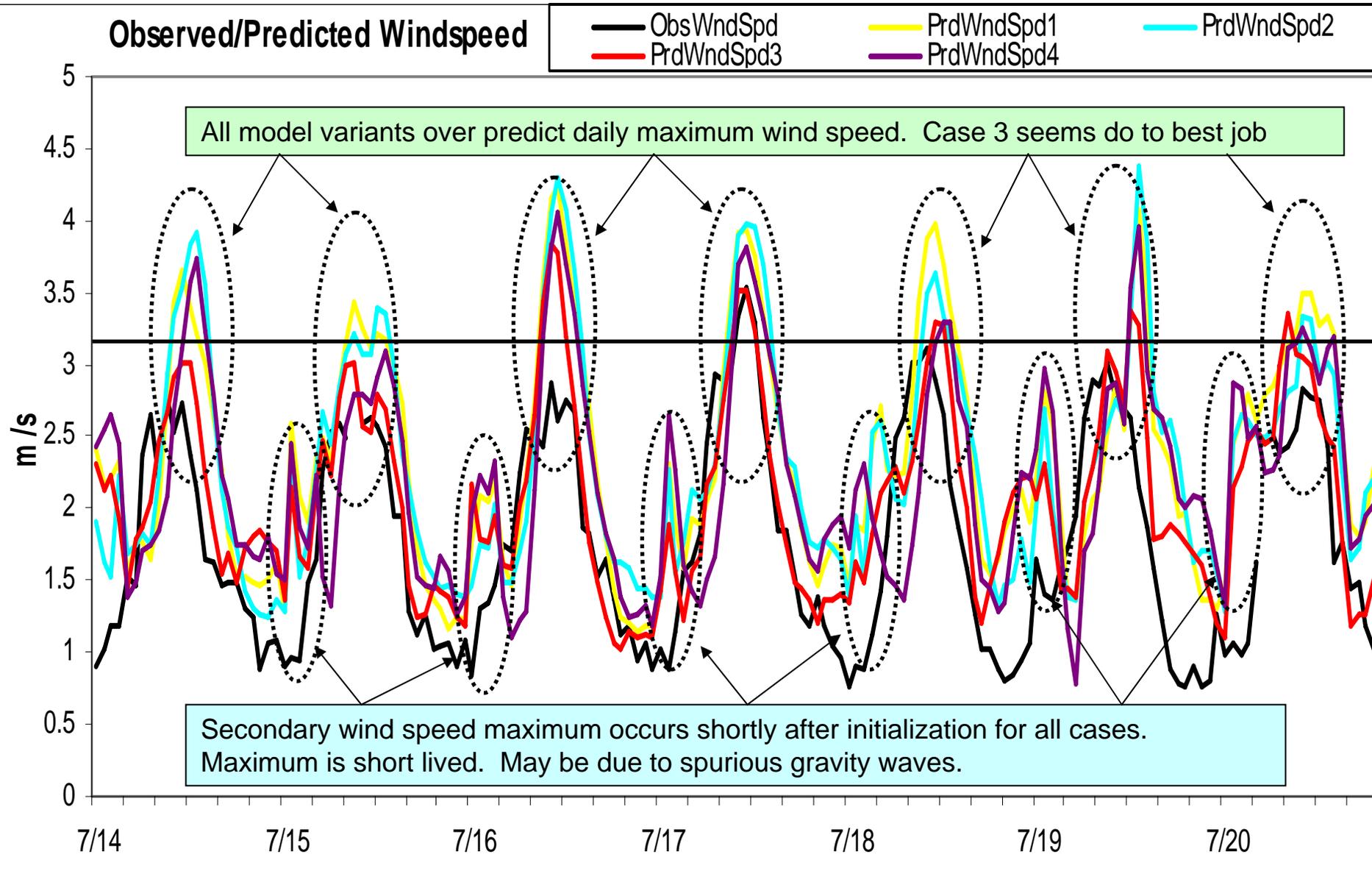
Approach to Met Model Evaluation

- Two high-ozone episodes: 14-19 Jul & 24-29 Aug 2005
- Daily 36-hour forecasts using 3-Cycle 3DVar data assimilation
- Five 3DVar/MM5 v3.7.2 model configurations
 - Case 1: RRTM, SLAB soil model, PBL5(MRF), Reisner cloud scheme
 - Case 2: RRTM, LSMw/AGRMET, PBL5(MRF), Reisner cloud scheme
 - Case 3: RRTM, SLAB soil model, PBL4 (ETA TKE), Reisner cloud scheme
 - Case 4: RRTM, SLAB soil model, PBL6 (G-S TKE), Reisner cloud scheme
 - Case b: RRTM, LSMw/AGRMET, PBL4 (ETA TKE), Reisner cloud scheme
- WRF: MAC Nested version WRF ARW 2.0, No 3DVar, 5km, hourly
- NAM: Saved NCEP NAM-12 (Tile 21), 3 hourly
- Verification:
 - Model-to-surface data hourly bias & rms statistics for each run and for each episode stratified by inland vs ocean/coastal sites *(Could not read MM5 Case 4 – no 2D fields)*
 - Also evaluated model-to-AQMD sfc data bias & rms statistics SCAQMD generated using METSTAT *(Could not read WRF, NAM or non-AQMD observations)*

Hourly Averaged Observed and Predicted Temperatures for Cases 1- 4, July Episode

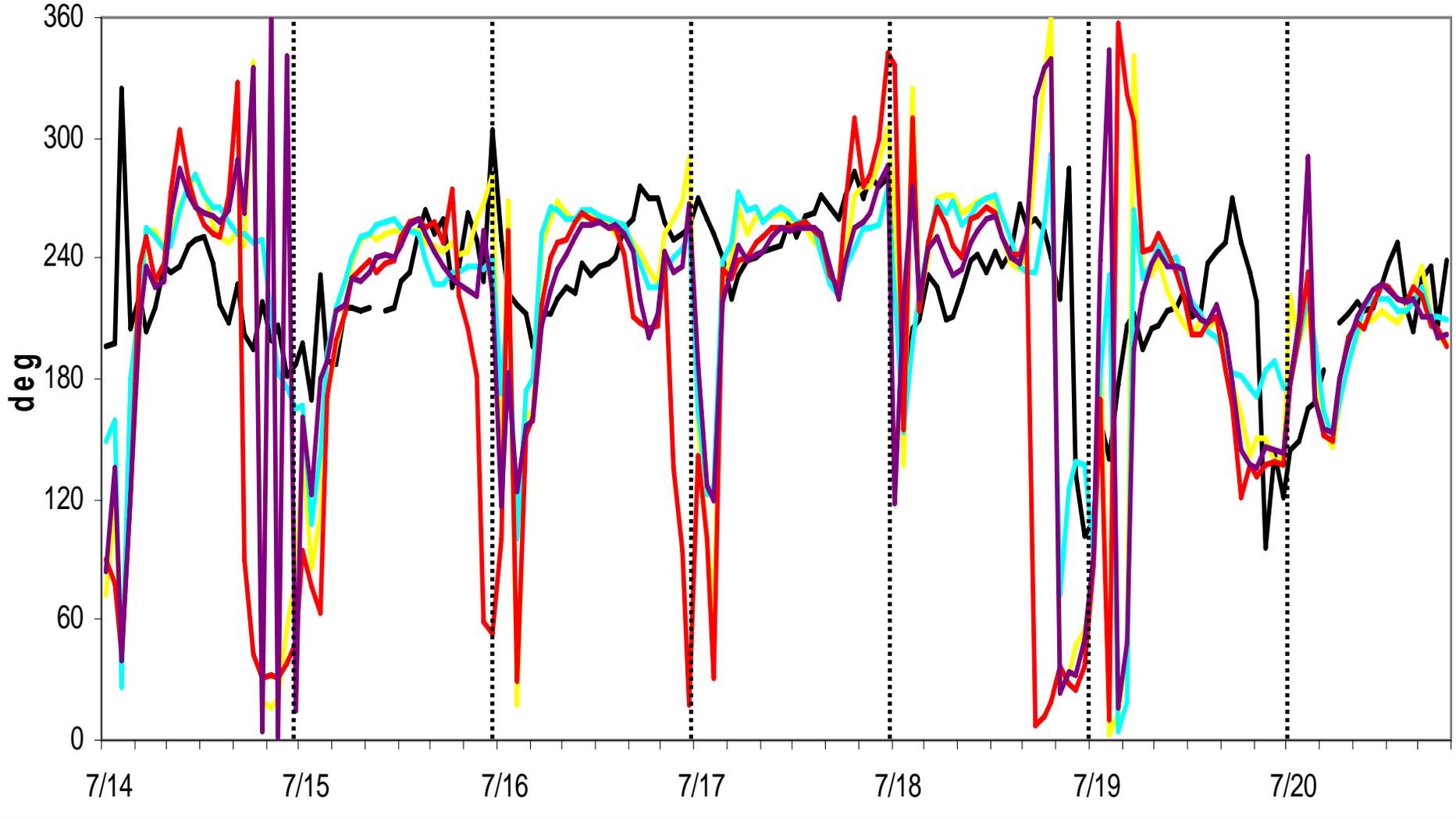


Hourly Averaged Observed and predicted Wind Speed Cases 1- 4, July Episode

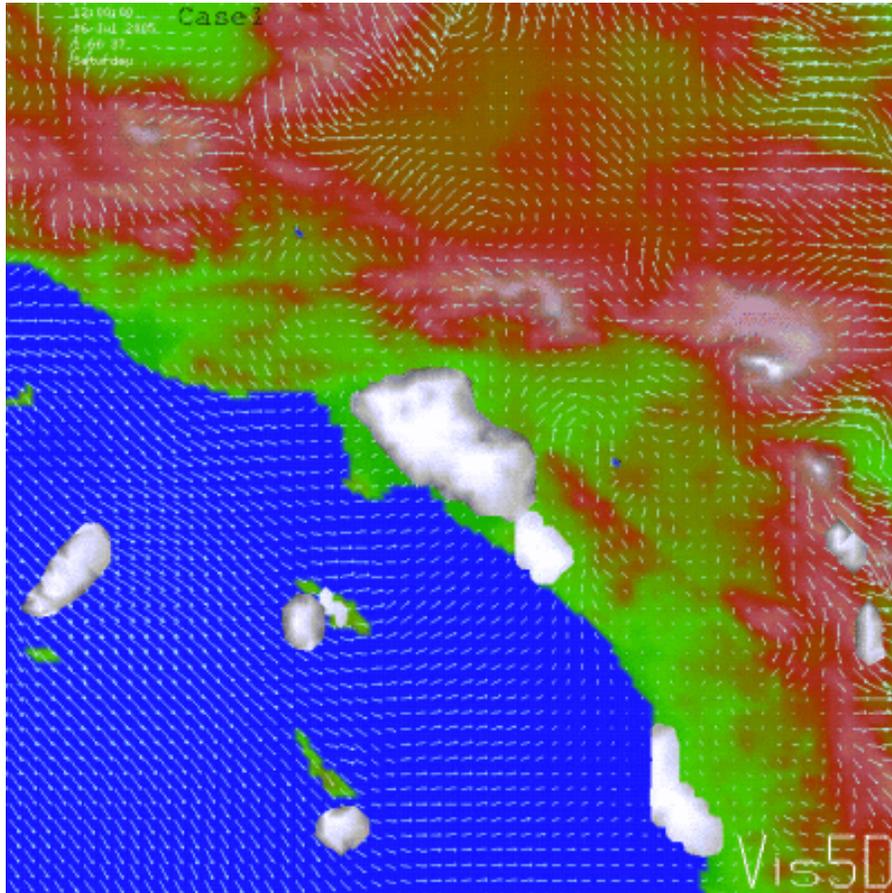


Hourly Averaged Observed and Predicted Wind Direction for Cases 1-4, July Episode

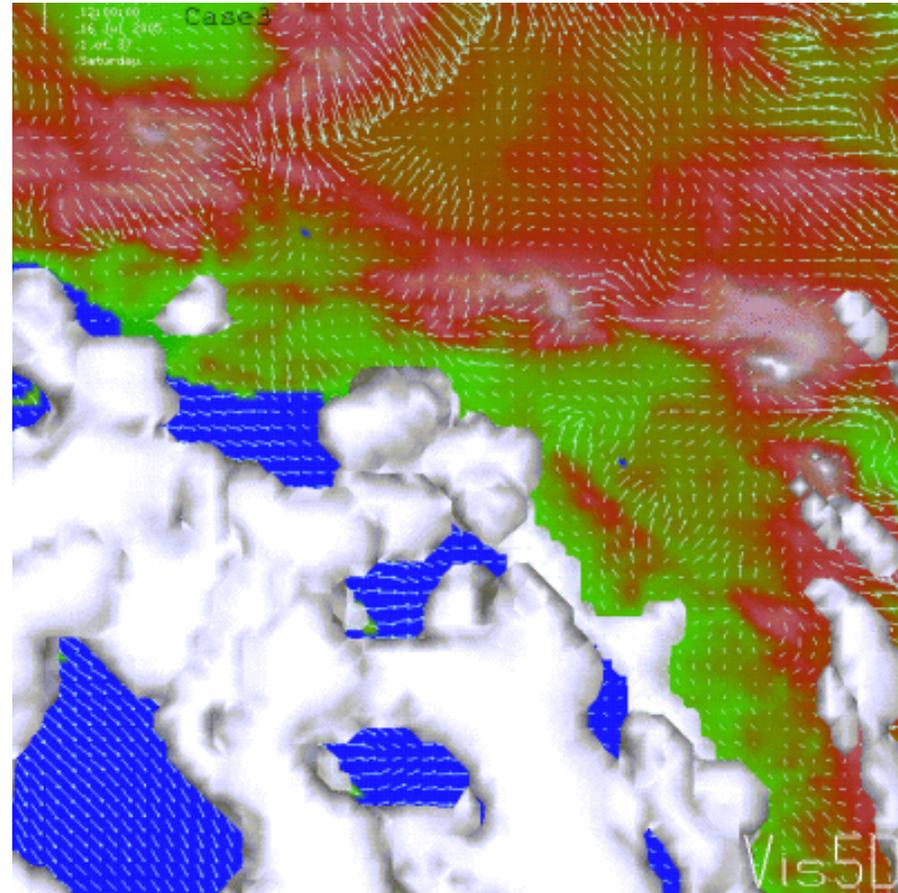
Observed/Predicted Wind Direction



Clouds and Lowest Model Level Winds, Case 1 and Case 3 July 16 2005 Forecast

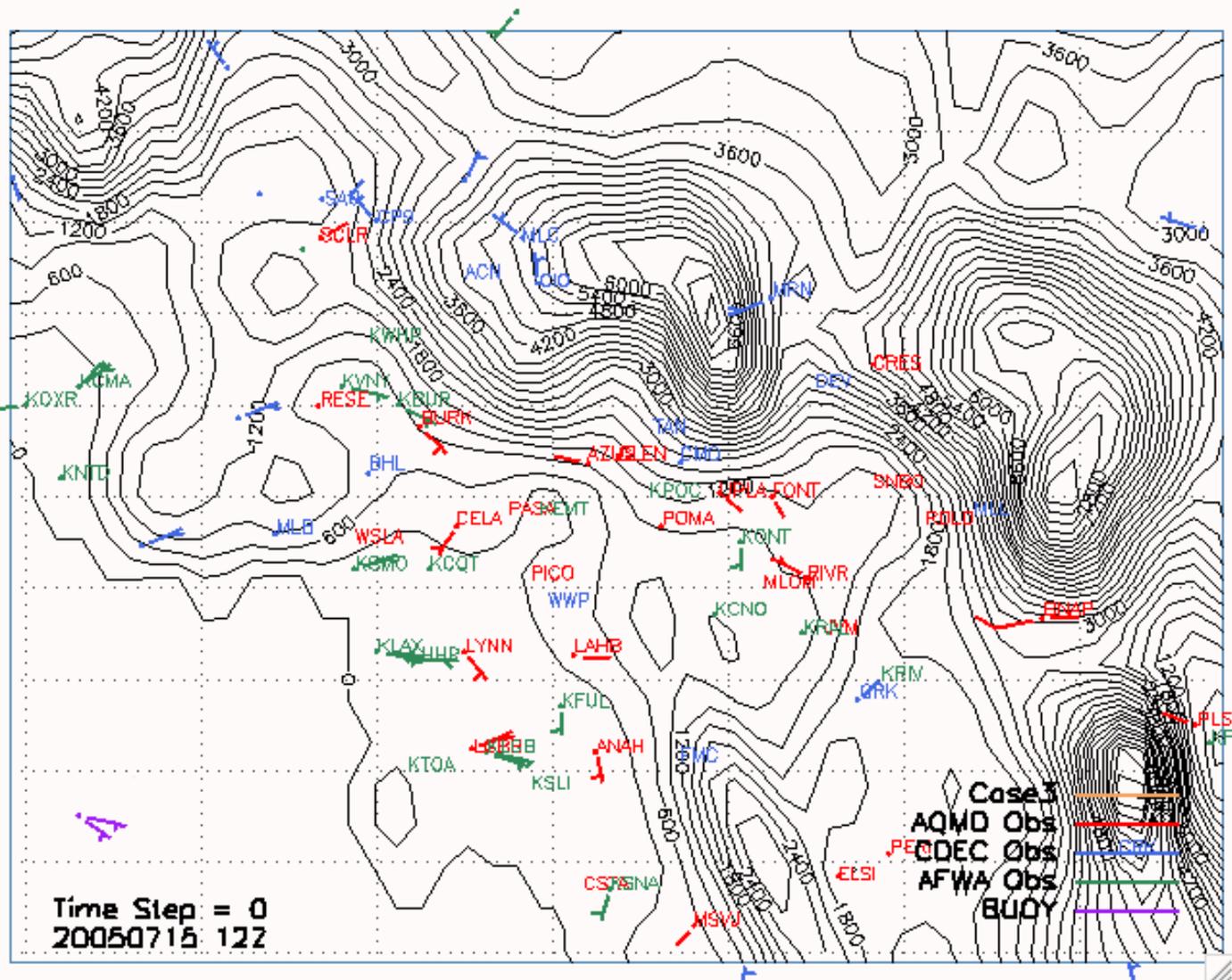


Case 1 (MRF PBL)

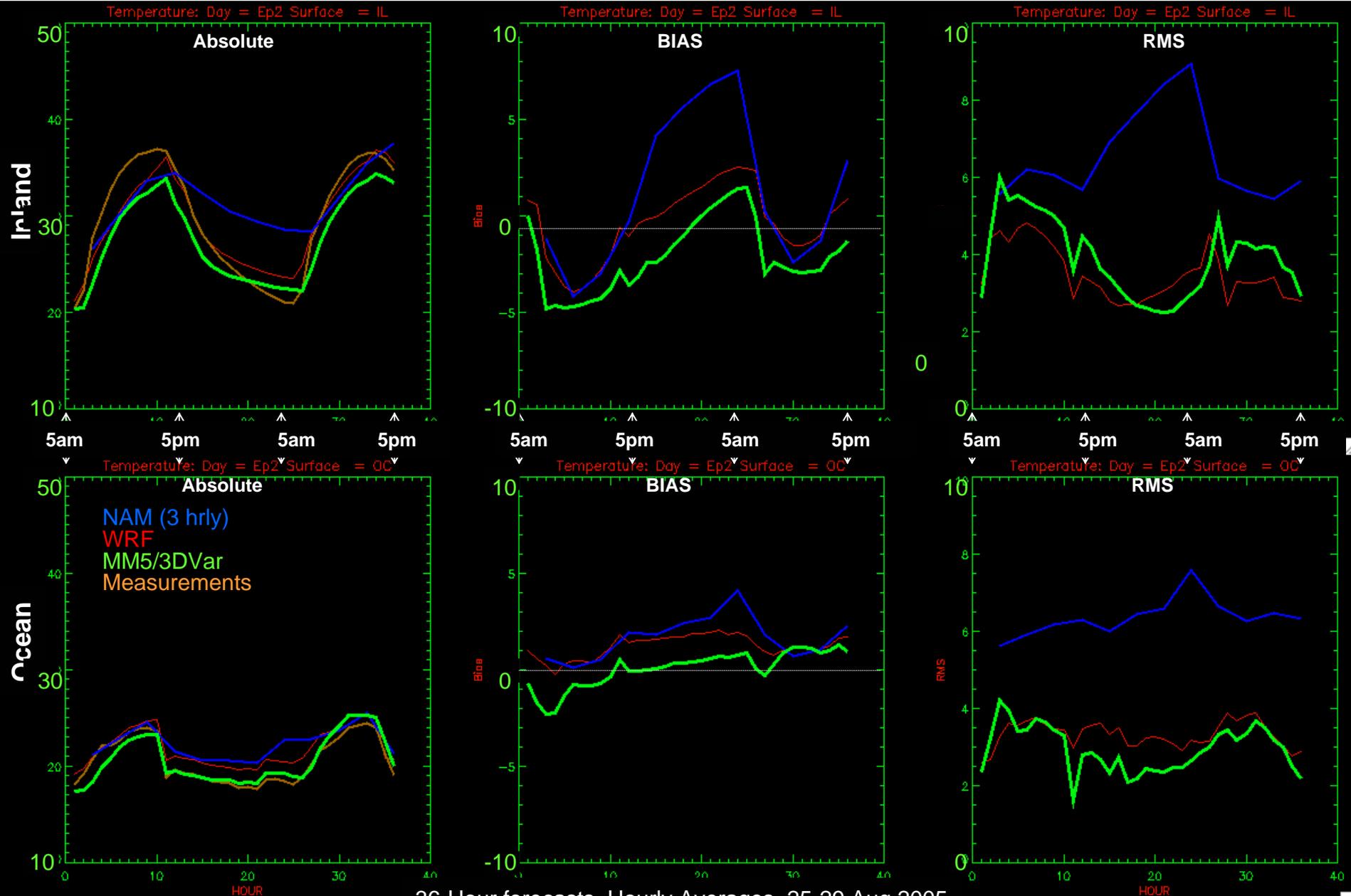


Case 3 (ETA PBL)

Observed and Predicted 2-meter Winds, Case 3 July 15 2005

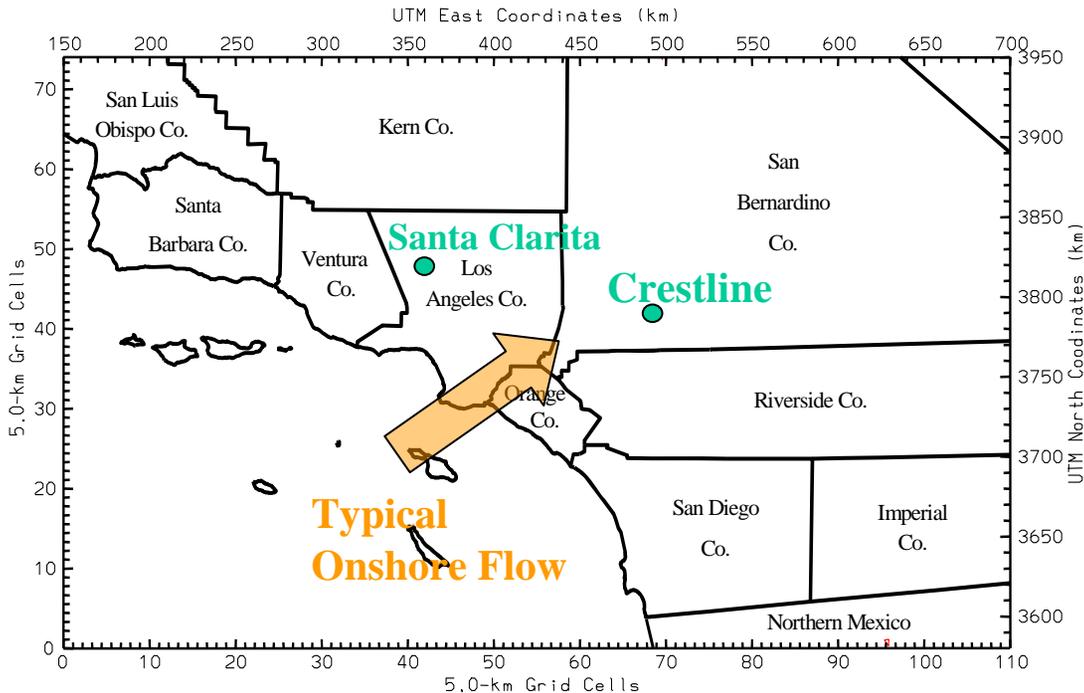


- # Temperature
- All models exhibit Max warm (or min cool) bias at 5am – most prominent inland
 - NAM has largest RMS – nearly twice that of WRF and MM5 (both inland and ocean)
- *Avg over all fcst hours
- NAM largest warm bias (0.9*); MM5 cool bias inland larger than WRF (-2.2 vs 0.8*)



36-Hour forecasts. Hourly Averages, 25-29 Aug 2005

Air Quality Model Description



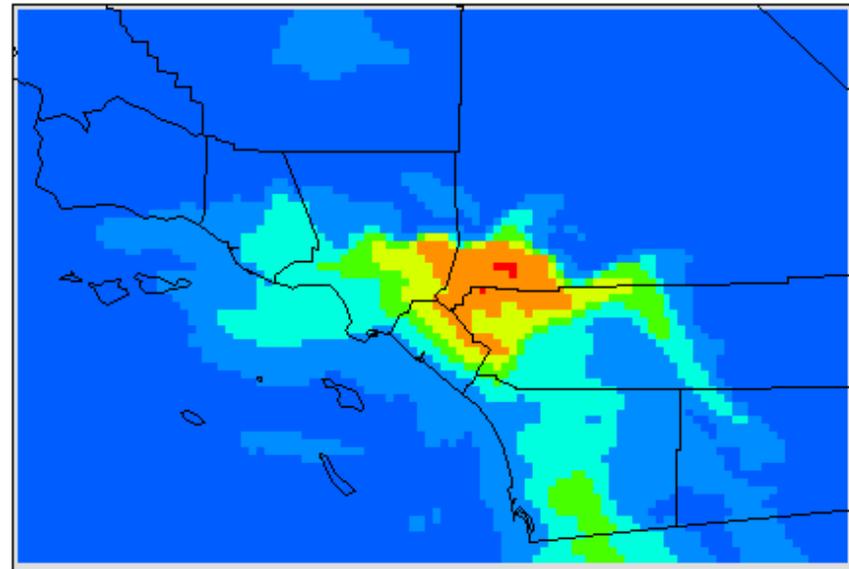
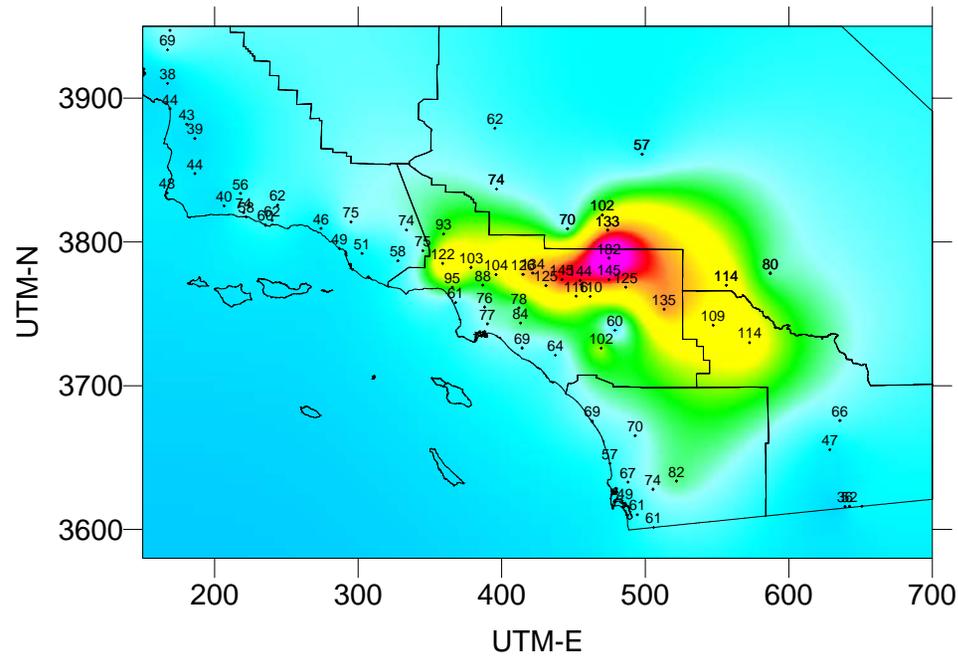
- 110 x74 Domain w/ 5km grid
- 16 layers with 5000m region top
- Fixed clean Initial, top and lateral boundary conditions:
 - VOC=20ppb
 - NO_x~0,
 - CO=200ppb,
 - O₃=40ppb

- Daily 36-hour forecast two high ozone episodes: 14-19 Jul & 24-29 Aug 2005
- Comprehensive Air-quality Model with extensions (CAMx) version 4.20
- SAPRC-99 Chemical Mechanism
- Enhanced emissions inventory to force ozone generation

Maximum Observed

Layer 1 O3c

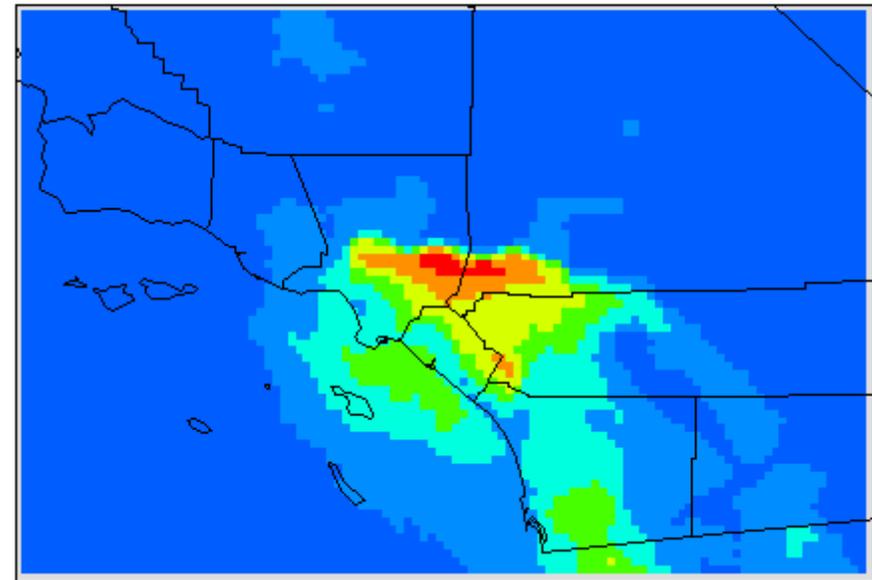
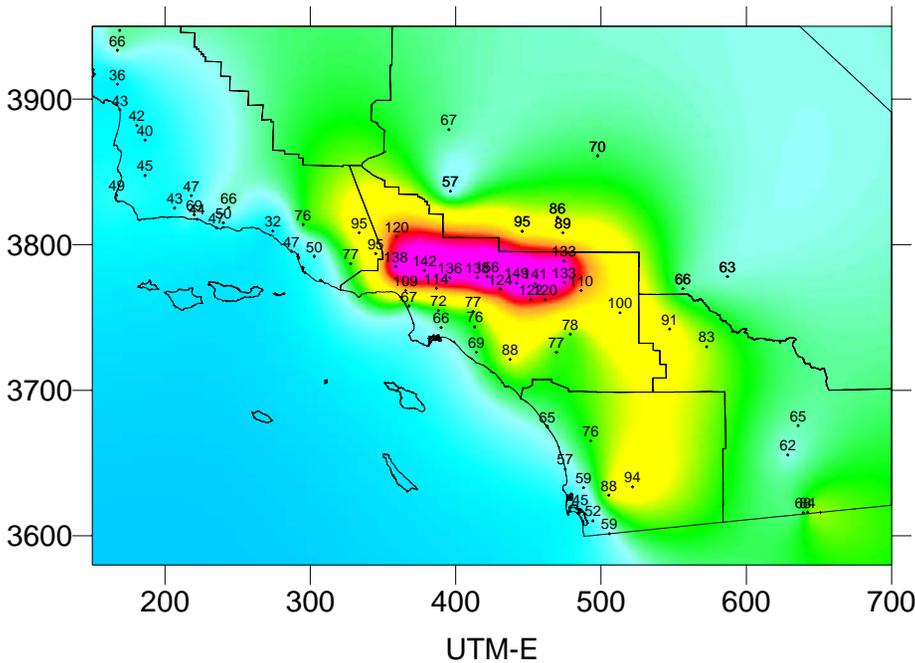
CAMx 4.20 - S99_Mech5 - August 27, 2005 c3e2s99
c=maxavc3e2s99.05239



Maximum Observed

Layer 1 O3d

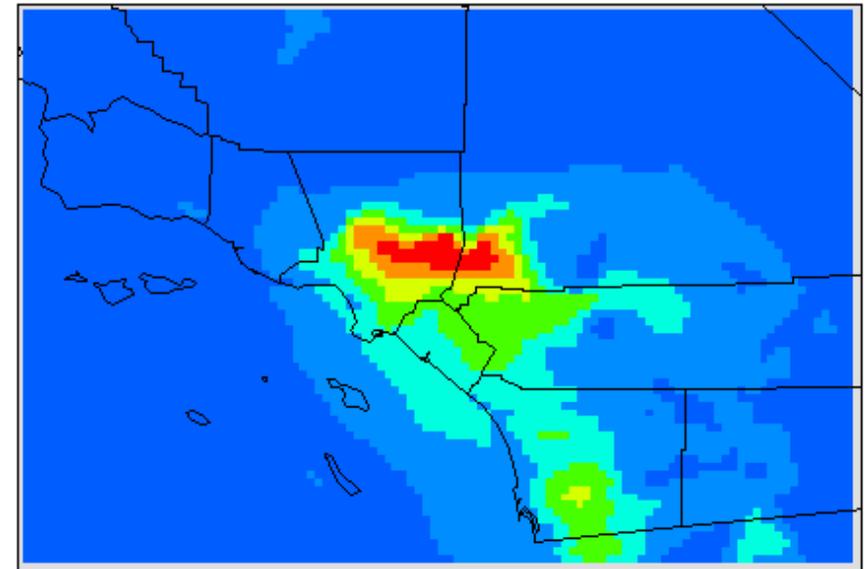
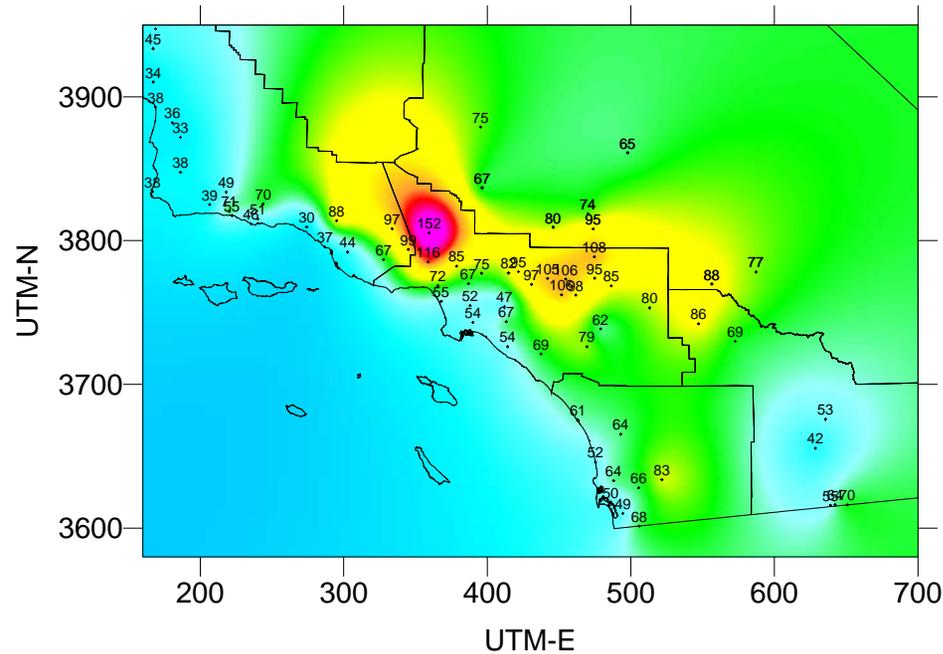
CAMx 4.20 - S99_Mech5 - August 28, 2005 c3e2s99
d=maxavc3e2s99.05240



Maximum Observed

Layer 1 O3e

CAMx 4.20 - S99_Mech5 - August 29, 2005 c3e2s99
e=maxavc3e2s99.05241

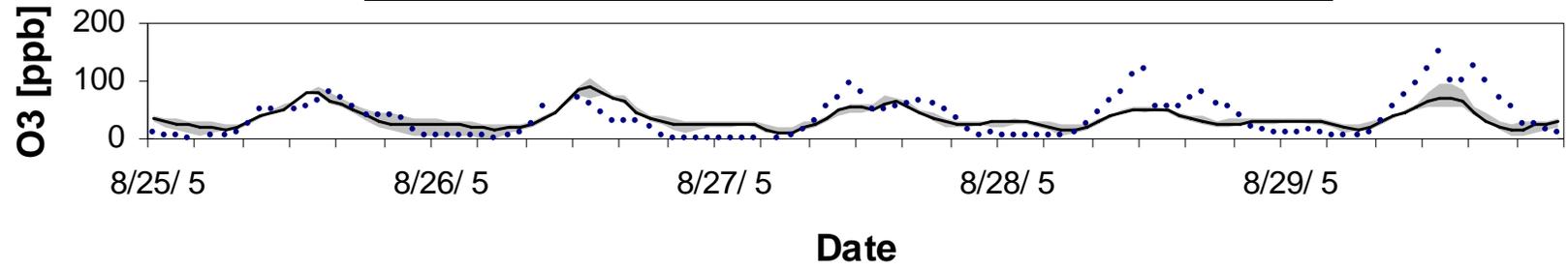


Timing of Ozone Peak August Episode

Northwest Basin

90: Santa Clarita 359.030 3805.530

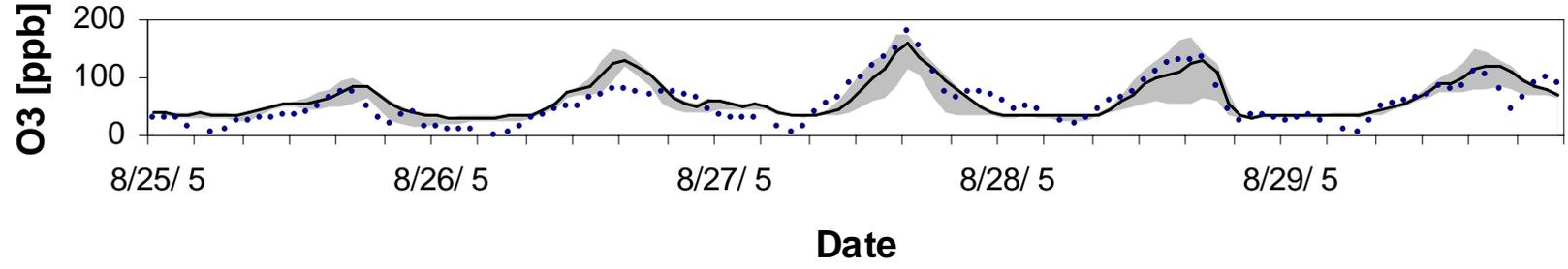
Minimum to Maximum Range · Observed — Predicted



Northeast Basin

5181: Crestline 475.500 3789.400

Minimum to Maximum Range · Observed — Predicted



Summary

- Most models variants do a reasonable job capturing the diurnal fluctuation in 2-meter temperature and 10-meter winds
- All models variants over predict the daily maximum temperature and the temperature over night (Case 2-LSM AGRMET is clearly the worst performer, Case 3-ETA/TKE BLP the best)
- Case b (not shown) - ETA-TKE combined with LSM AGRMET - did not improve the warm bias seen in Case 2-LSM AGRMET
- All models over predict the daily maximum wind speed
- Anomalous secondary wind speed maximum noted
- Excessive turning of winds to a southeasterly direction in early morning (possible anomalous down-slope flow)

- Complete PBL height verifications
- Verification against sounding data
- Additional Modeling Configurations
 - MM5/3DVar with ISOIL3 and PBL7 (Pleim-Chang)
 - MM5/3DVar with NOAA LSM without AGRMET
 - WRF for July episode
 - Cycled runs
- Re-run CAMx with updated emissions
- Continue to evaluate performance to the Santa Clarita Valley (Northwest Basin)
 - Backward Trajectory (RIP)
 - Forward Trajectory (In-house Multi-Particle Dispersion Code - MPDM)

Sneak Preview Trajectory Analyses

- Read/Interpolate/Plot (RIP) Backward Trajectories: Specify the endpoint of the trajectory and reverse the integration in time to determine the source of an air mass
 - 3 Pm start time corresponding peak Ozone observations at Santa Clarita and Crestline
 - Back - Propagate 12 hours
 - 10, 50, 100m release points
- Lagrangian Multi-Particle Dispersion Model (MPDM) Forward Trajectories
 - Four release areas release points in the LA Basin
 - > San Fernando Valley,
 - > West LA/South Bay,
 - > Downtown/SouthLA,
 - > Burbank/Glendale
 - 6am forward propagation to 3pm
 - 3D – winds

Aerospace MM5 Trajectories

Init: 1200 UTC Sun 17 Jul 05

Fest: 10.00

Valid: 2200 UTC Sun 17 Jul 05 (1500 PDT Sun 17 Jul 05)

Temperature

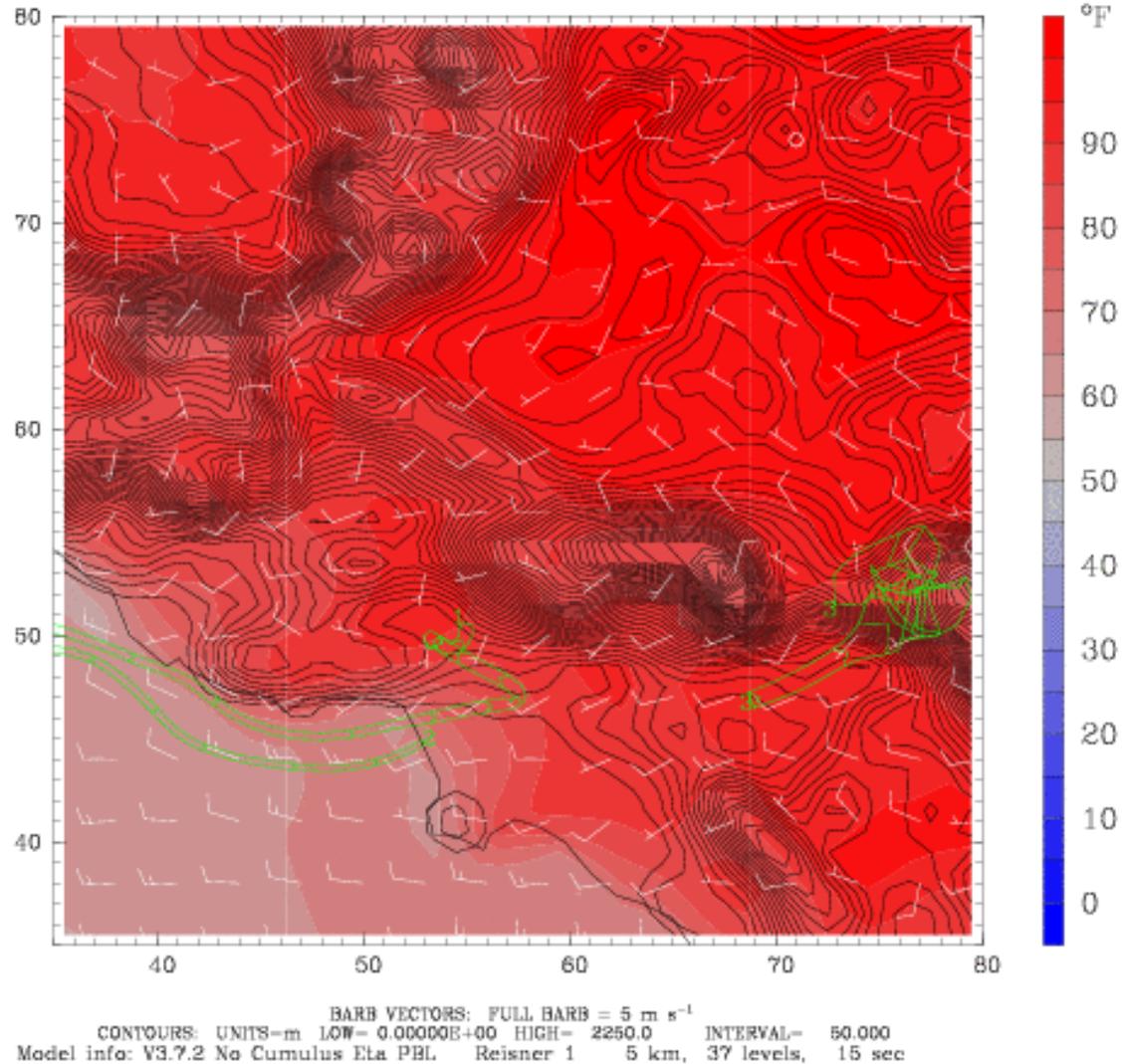
at height = 0.01 km

Terrain height AMSL

Horizontal wind vectors

at height = 0.01 km

Trajectories from hour 10.000 to 22.000



Example: RIP Backward Trajectory



MM5 run: July 16, 2005, Case 3, 6am to 3pm local (PDT) time
San Fernando Valley (grey), West LA/parts of South Bay (red), Downtown/SouthLA (blue), Burbank/Glendale (yellow)
Screenmode to Animate

Example: MPDM Forward Trajectory