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A Comparison of Meteorological Simulations Created using Nudging and 3DVAR for a High-Ozone Episode in the Los Angeles Basin

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Overview/Background

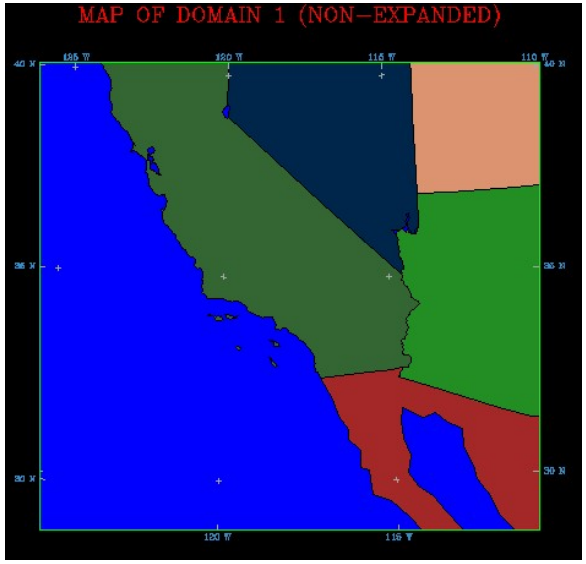
- Original Intent: Generate meteorological and air quality model forecasts for Southern California during the summer of 2005 for comparison to the EPA-NOAA National Air Quality 5X developmental forecasts

- Current Activity: Comparing the accuracy of simulations made using nudging against those using a rapidly updating 3DVAR

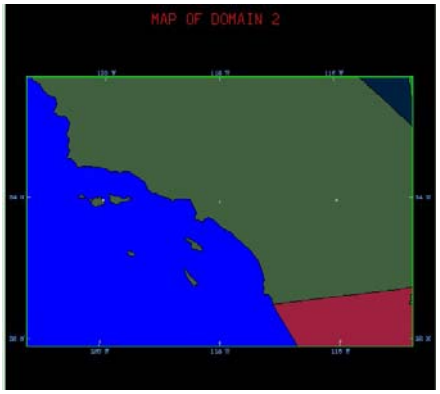
- Objectives of the analysis include:
  - Determine if a rapidly updating 3DVAR provides any valued added over nudging as employed by the SCAQMD in their meteorological simulations for air quality applications
  - Determine the level of spurious gravity wave activity in the two simulations

Meteorological Simulation System Description

www.aerospaceweather.com



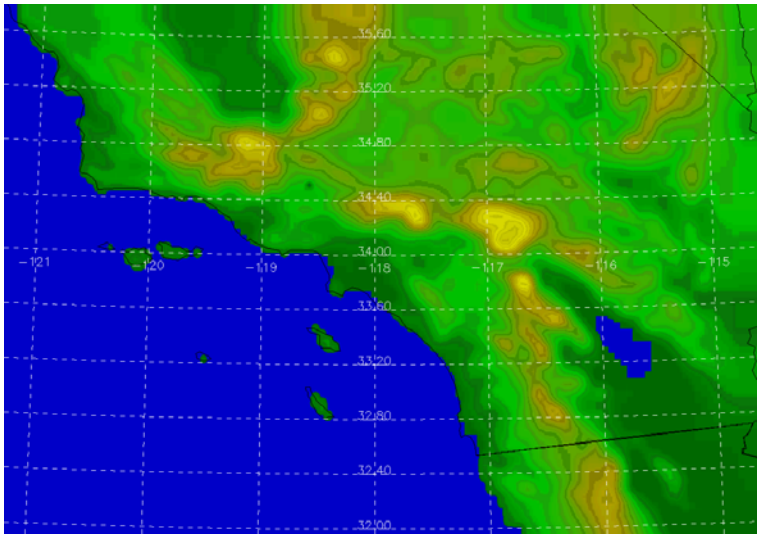
Outer Domain 1 ($\Delta x = 15$ km)



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

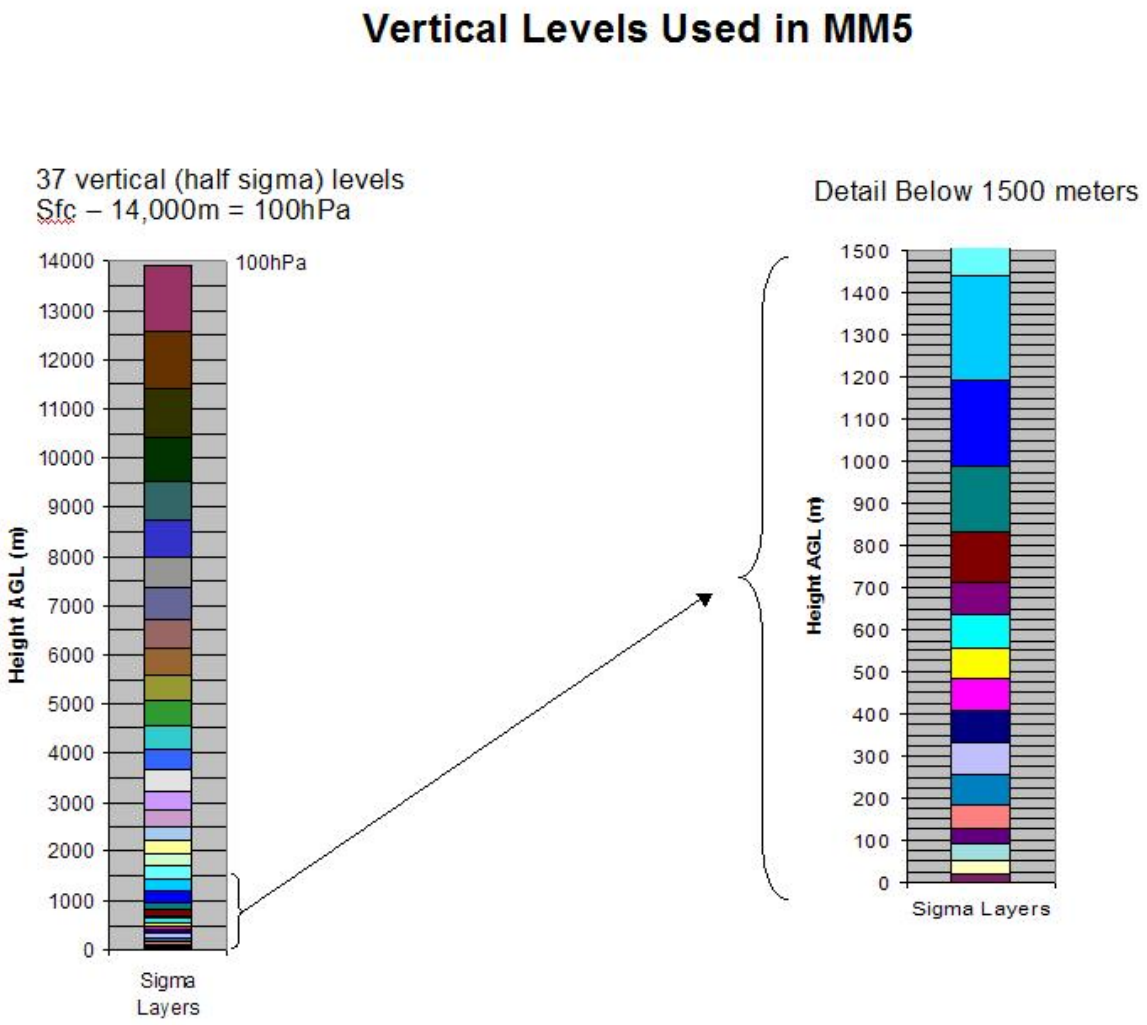
MM5 3-Dimensional Variational Analysis System (3DVAR)

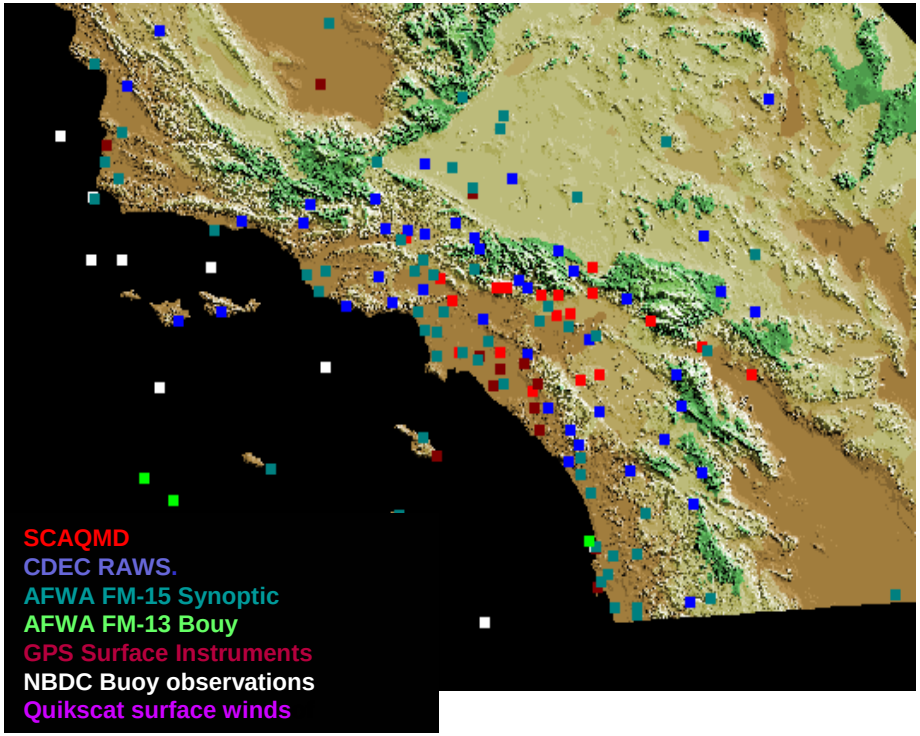
- A wide variety of local and remotely sensed observations are assimilated
- Continuous data assimilation cycle employed for both outer and inner domain
- Background errors computed for each domain

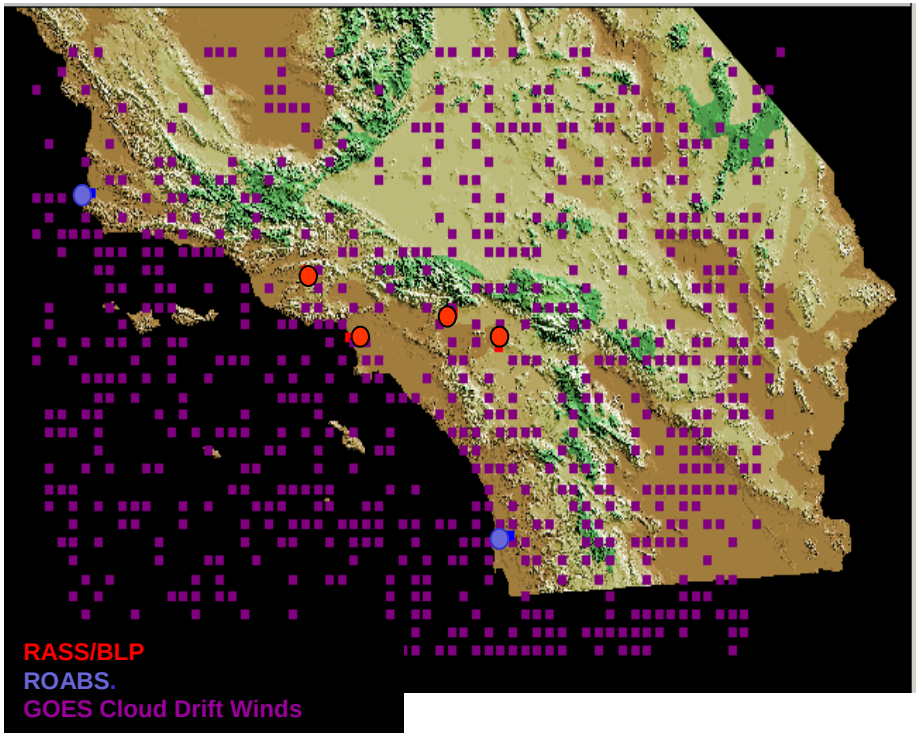


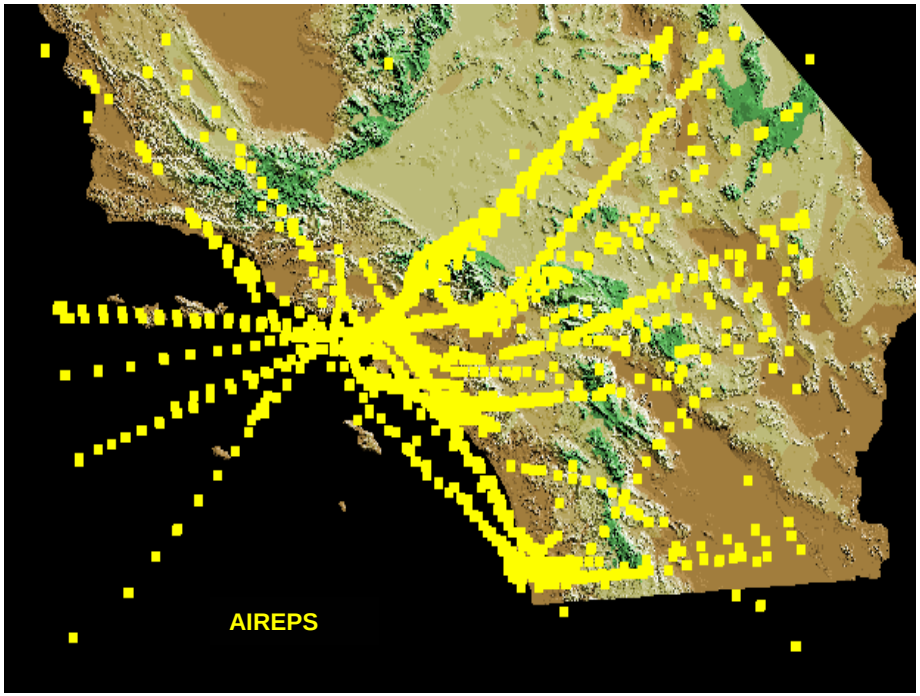
Terrain of Inner Domain

Vertical Level used in MM5



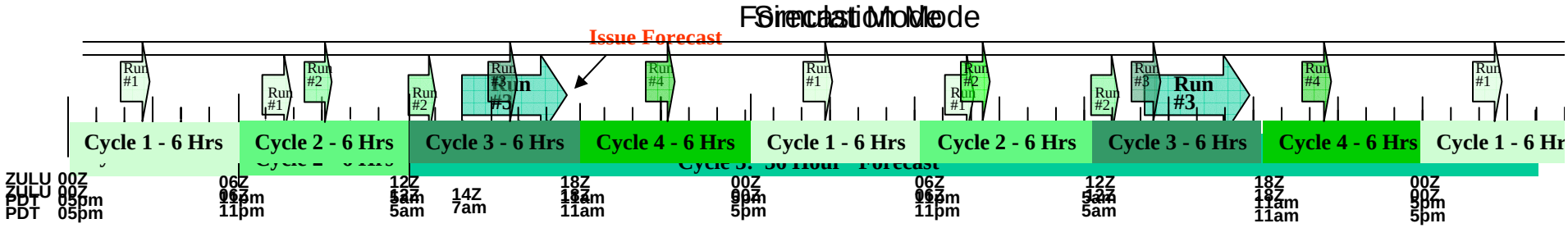






- Examples of observation types their distribution
- All observations types are assimilated and used for verification
- Only the SCAQMD observations are used by the MetStat verification system

Model Concept of Operations

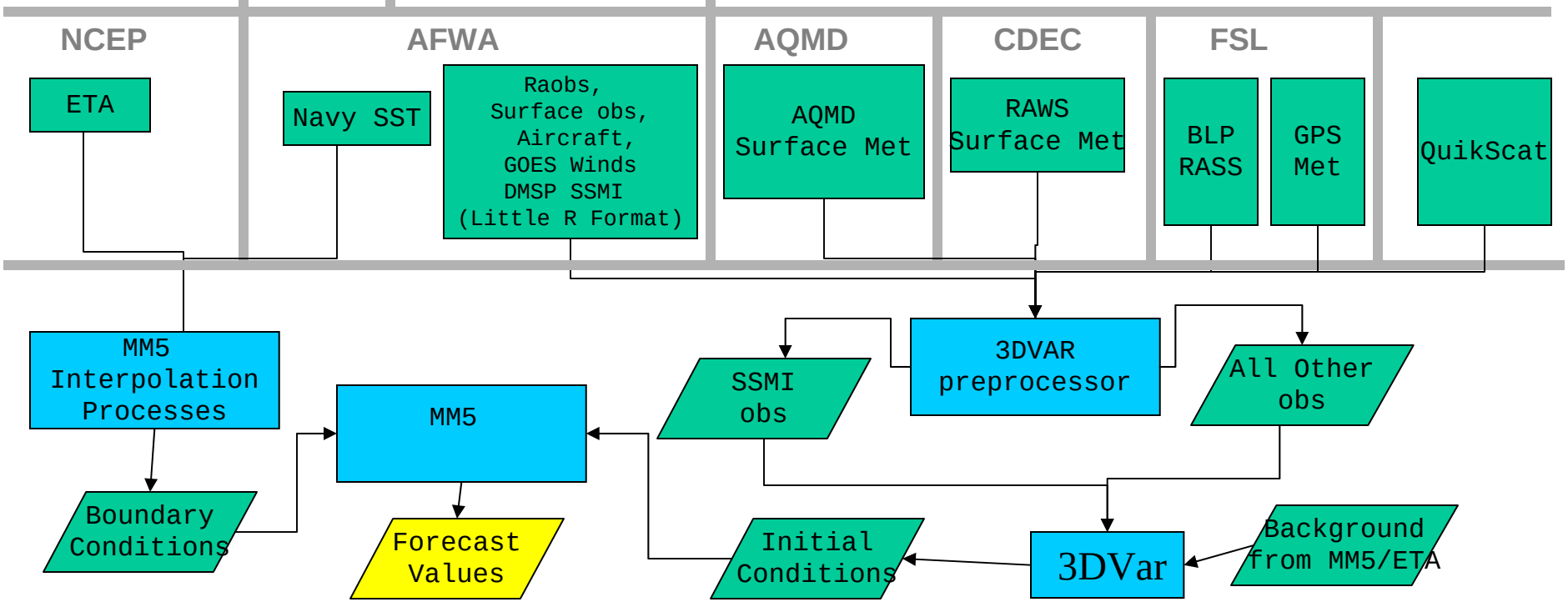


Cycle 1: Pull ETA 00Z out 6hrs
Cycle 2: Pull ETA 06Z out 42 hrs

Daily at 12Z for previous day

Cycle 1: Pull 00Z obs at 05:50Z
Cycle 2: Pull 06Z obs at 11:50Z
Cycle 3: Pull 12Z obs at 13:30Z

Hourly



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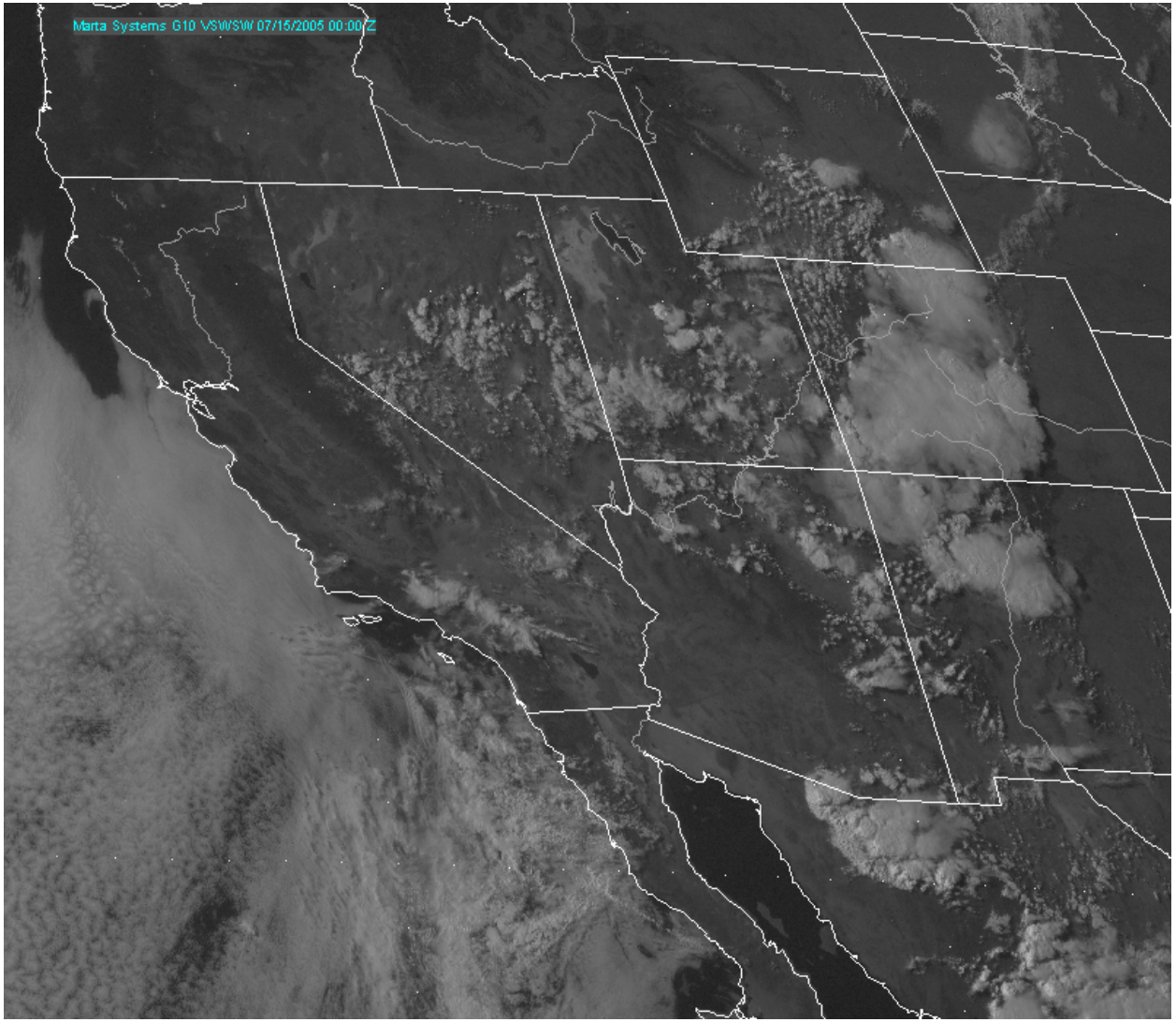
Large Scale Conditions Present During High-Ozone Episode



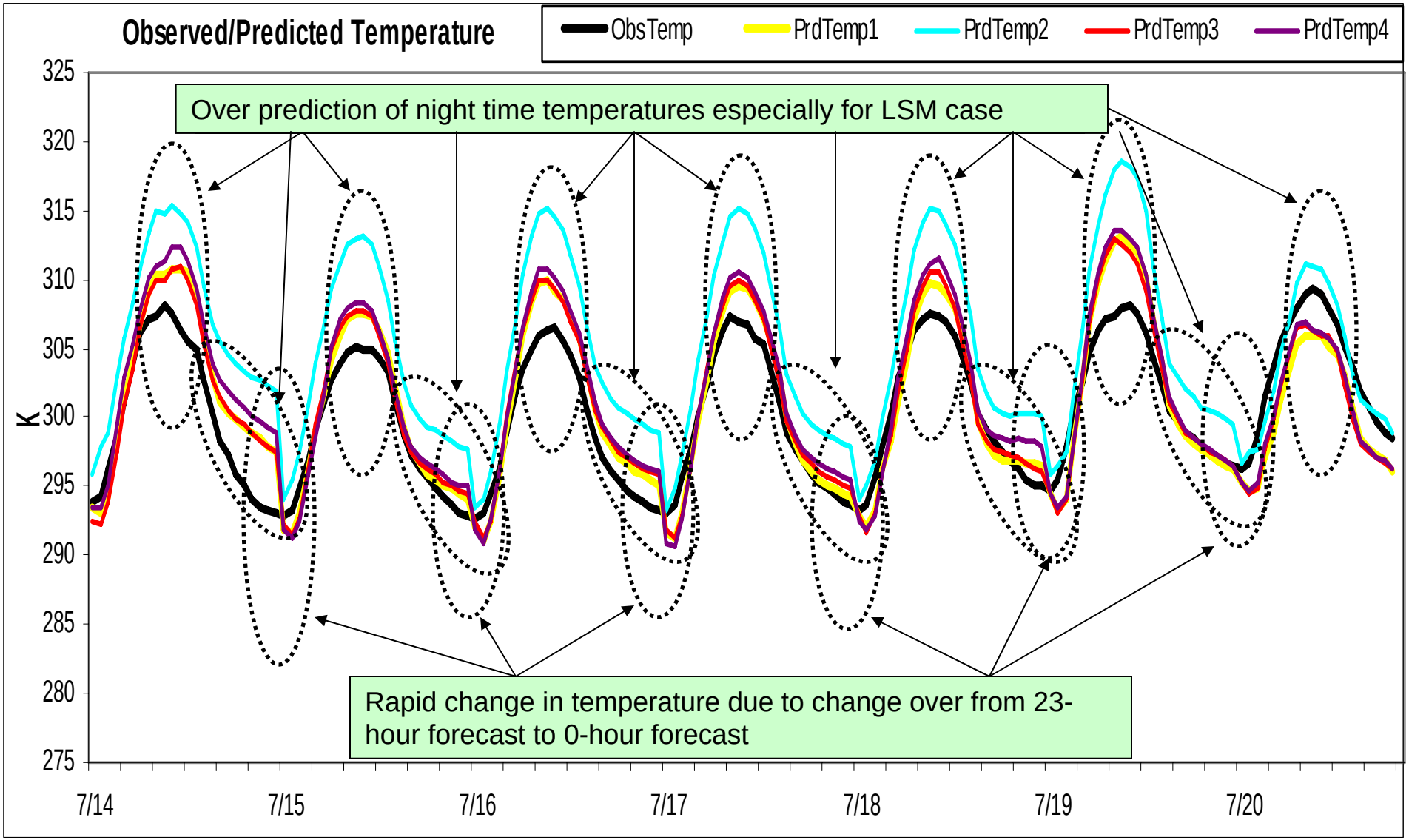
GOES Visible Imagery, 15 Jul 2005 00Z

- 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

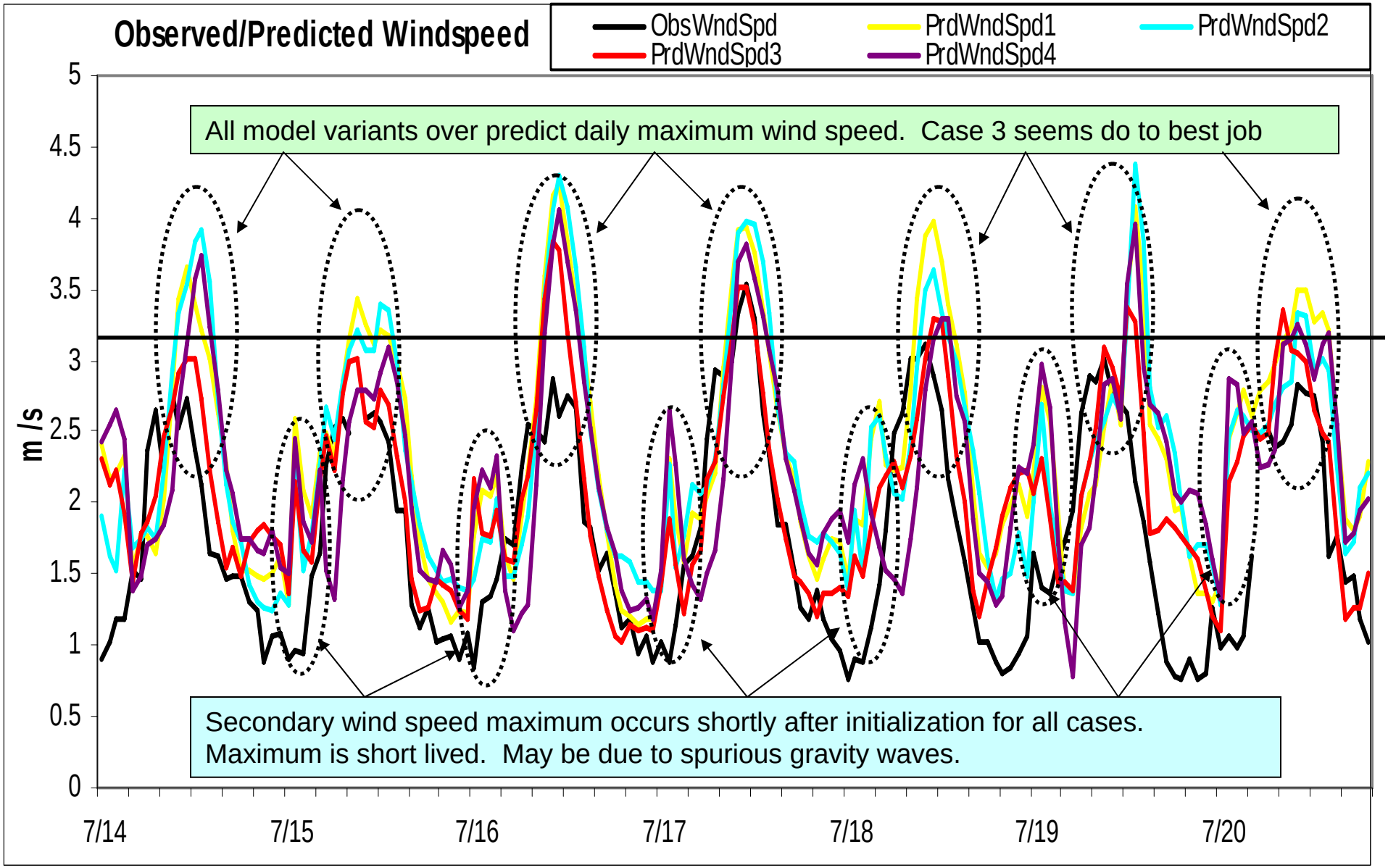
Approach to Met Simulation Comparisons

- High-ozone episode: 14-19 Jul
- 6-hour forecasts using 4-Cycle 3DVar data assimilation compared to SCAQMD nudged run for the inner most domain (5km grid spacing)
- Five 3DVar/MM5 v3.7.2 model configurations considered
  - 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
- Case 3 chosen because of its superior performance over the period
- Verification:
  - Model-to-surface data hourly bias & rms statistics stratified by inland vs ocean/coastal sites
  - Qualitative evaluation of model low-level wind fields and vertical velocity to identify gravity wave activity

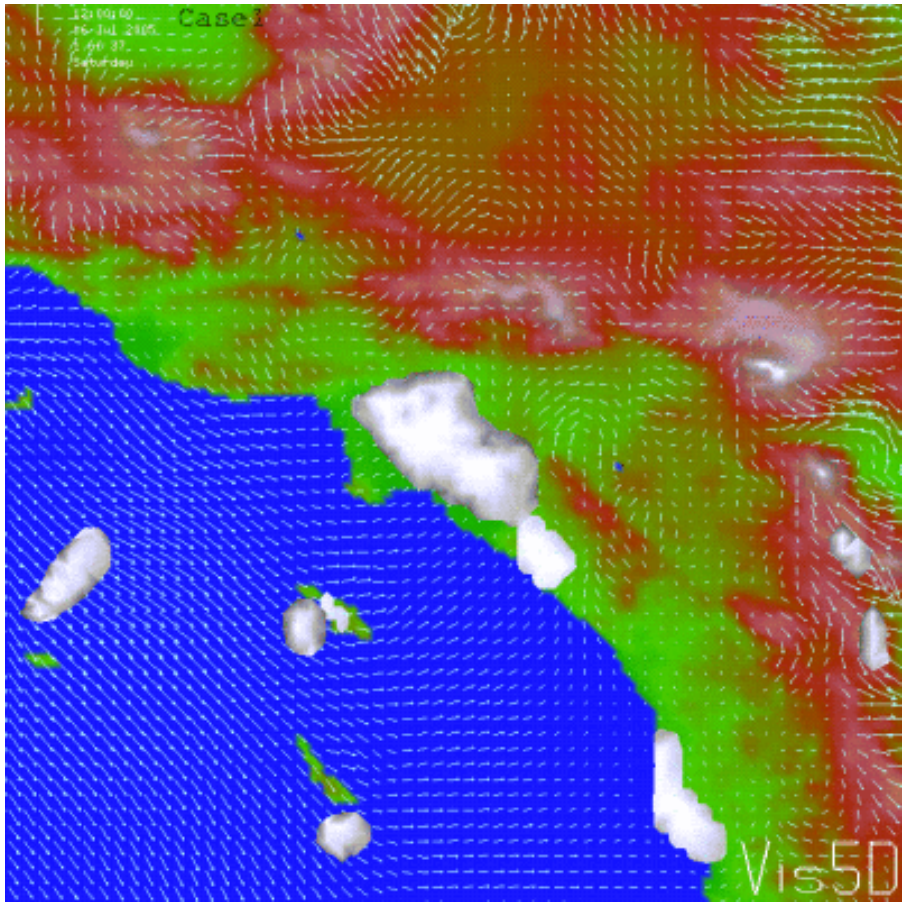
Hourly Averaged Observed and Predicted Temperatures for Cases 1- 4, July Episode



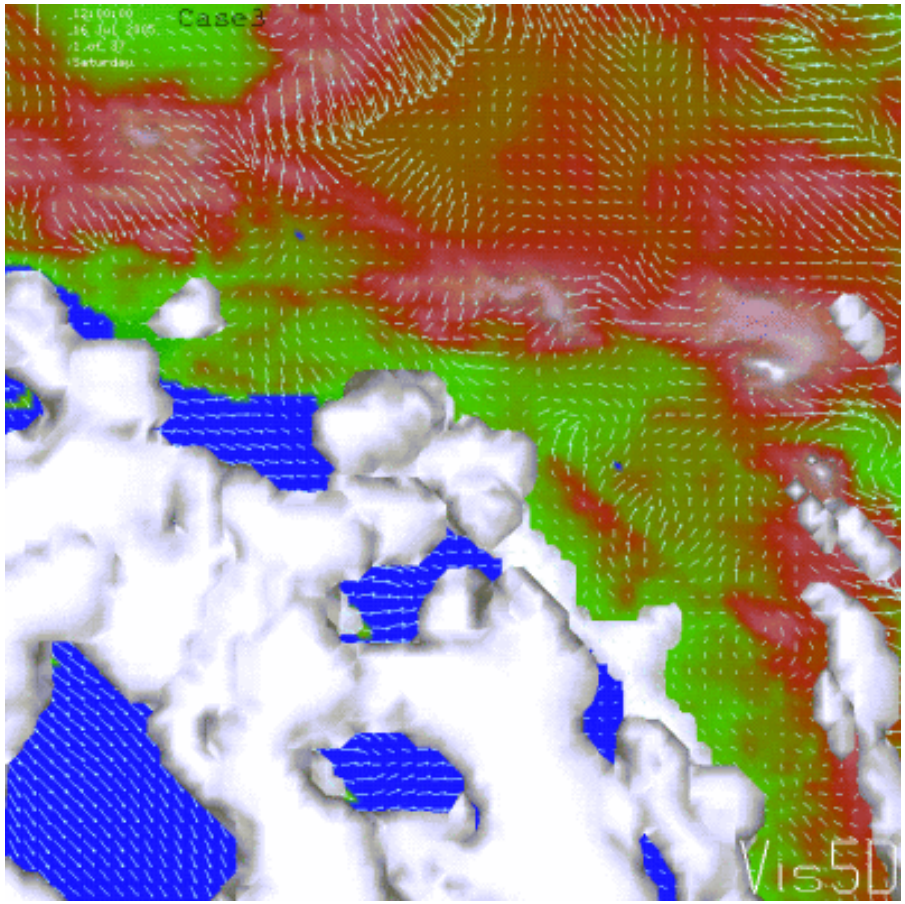
Hourly Averaged Observed and predicted Wind Speed Cases 1- 4, July Episode



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



Case 1 (MRF PBL)



Case 3 (ETA PBL)

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SCAQMD Model Configuration

- 3 grids (45, 15, 5km)
- 2-way nesting
- 34-levels with ptop at 100mb
- MM5 version 6.1
- no cloud ice or snow in model only cloud liquid water and rain.
- ISOIL=1 5-layer slab model no LSM
- IFRAD=1 Simple cooling. Atmospheric cooling depends just on temperature (No cloud interaction or diurnal cycle). Surface radiation diurnally varying short and longwave. Fluxes depend on integrated precipitable water. Low/middle/high cloud determined from RH
- ICUPA=3 Grell cumulus parameterization on all domains (we didn't use the cumulus parameterization on the Aerospace 5km domains)
- IMPHYS=4 Simple Ice no supercooled water
- IBLTYP=3 ETA TKE scheme

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SCAQMD Nudging Configuration

- NCEP Final Analysis (FNL) for initial and lateral boundary conditions
- Analysis nudging on the 45 and 15 km domains for wind, temperature and mixing ratio…no nudging in the PBL
- Observation nudging, wind only, for the 5km domain with pseudo raobs extracted from a CALMET analysis

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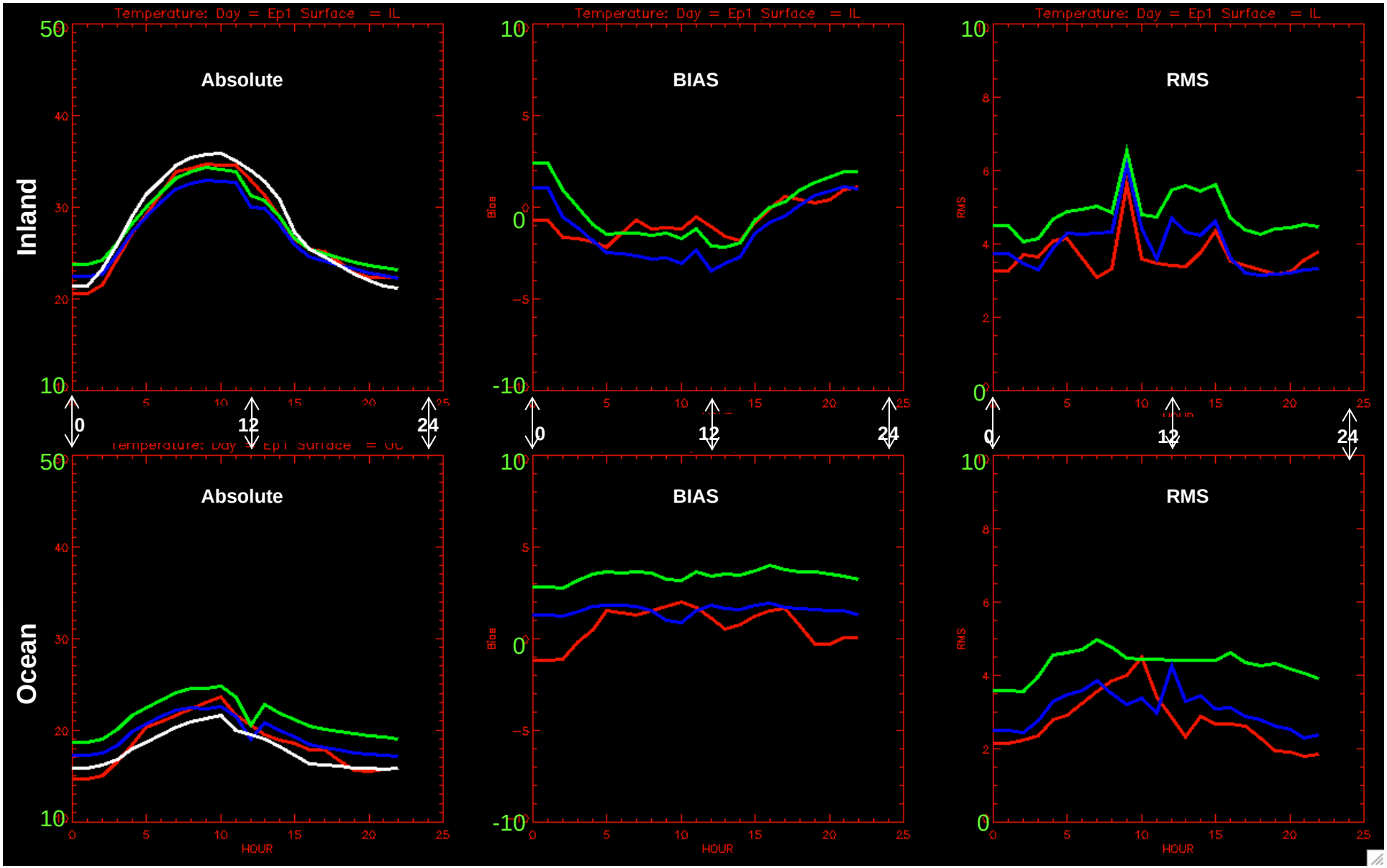
Temperature July 14-17

White, Measured
Red: Aerospace cycled
Green: AQMD, nofdda
Blue: AQMD, fdda

Plots generated 06 June 07



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Wind Speed July 14-17

White, Measured
Red: Aerospace cycled
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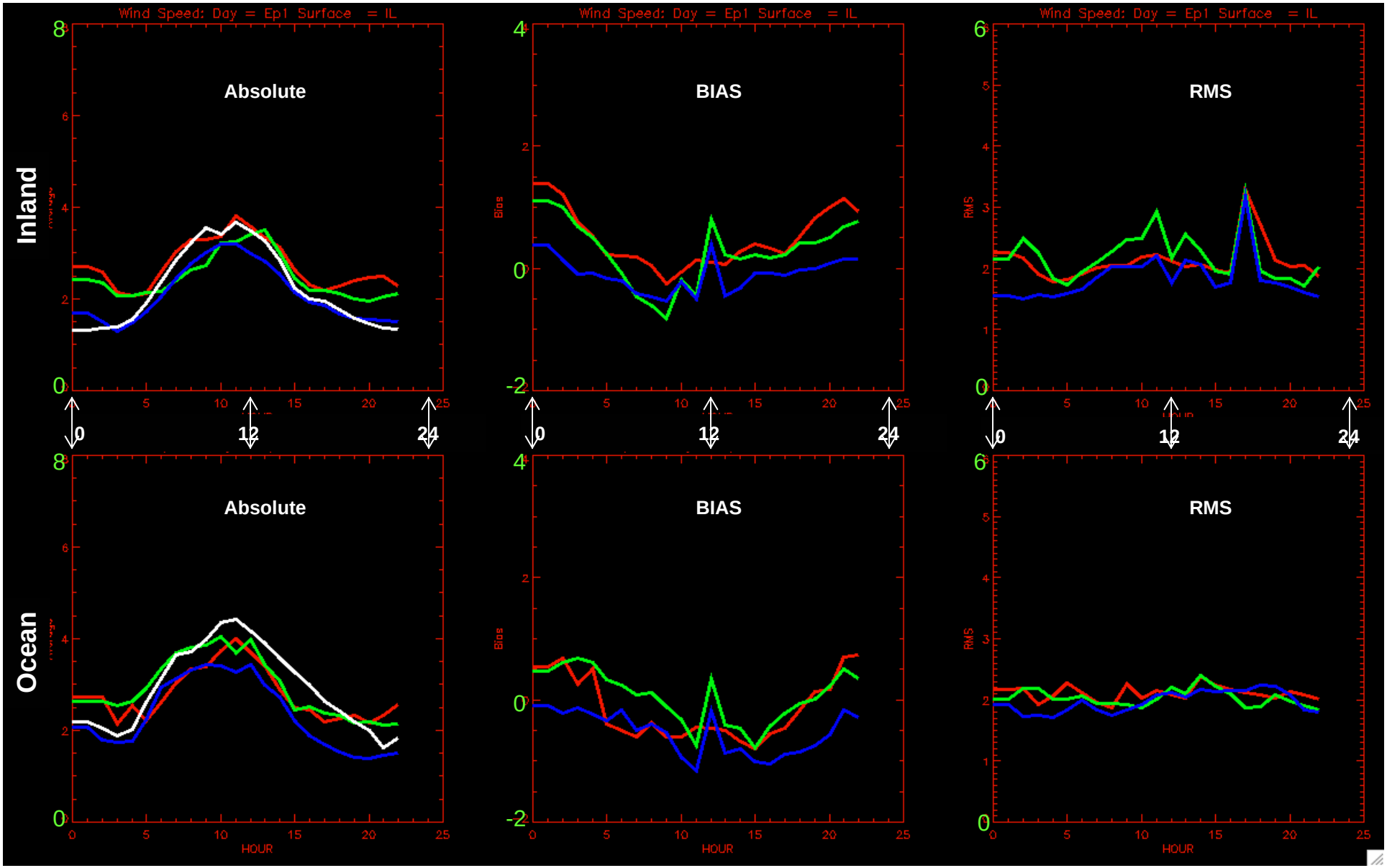
Blue: AQMD, fdda

Plots generated 06 June 07



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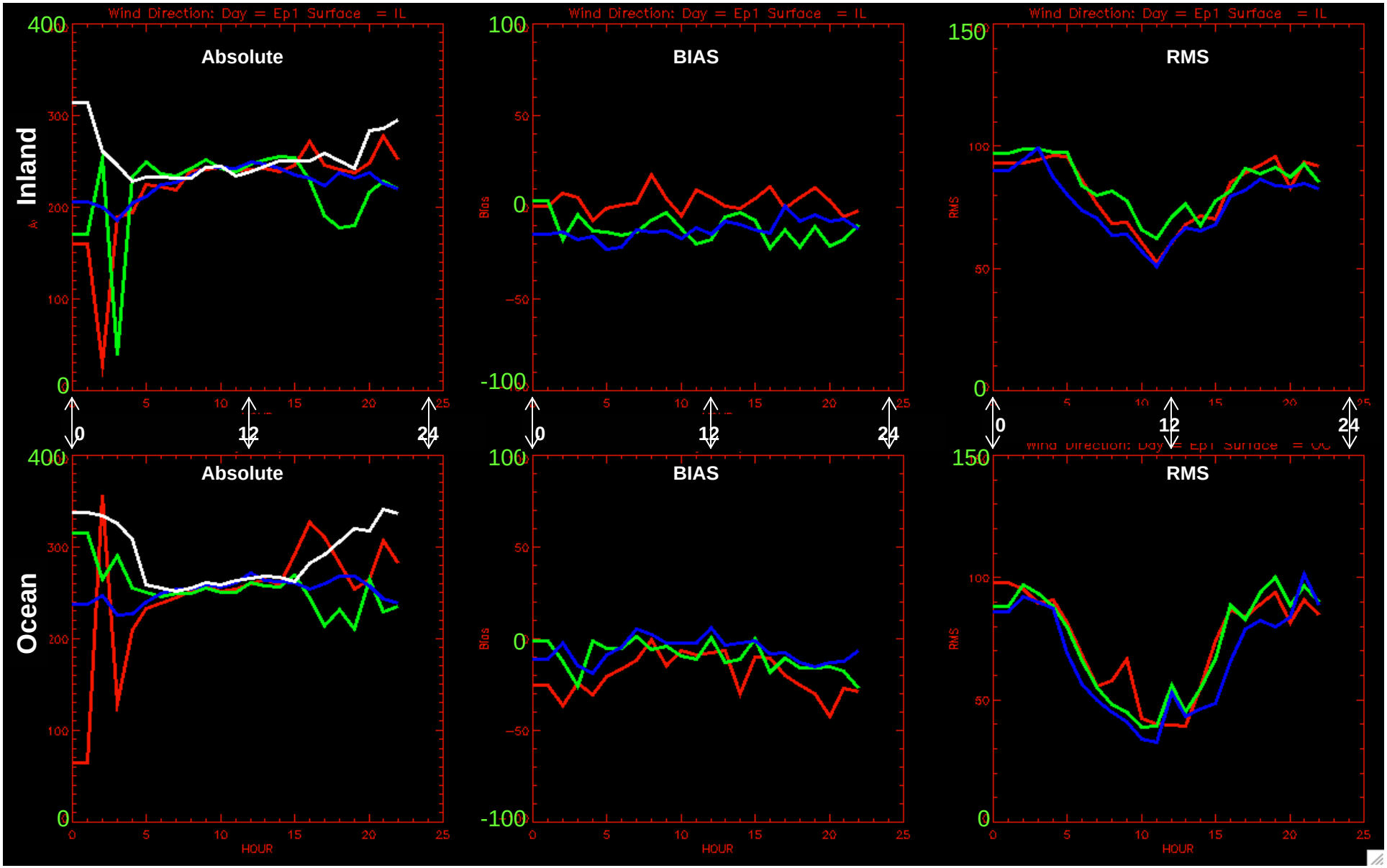
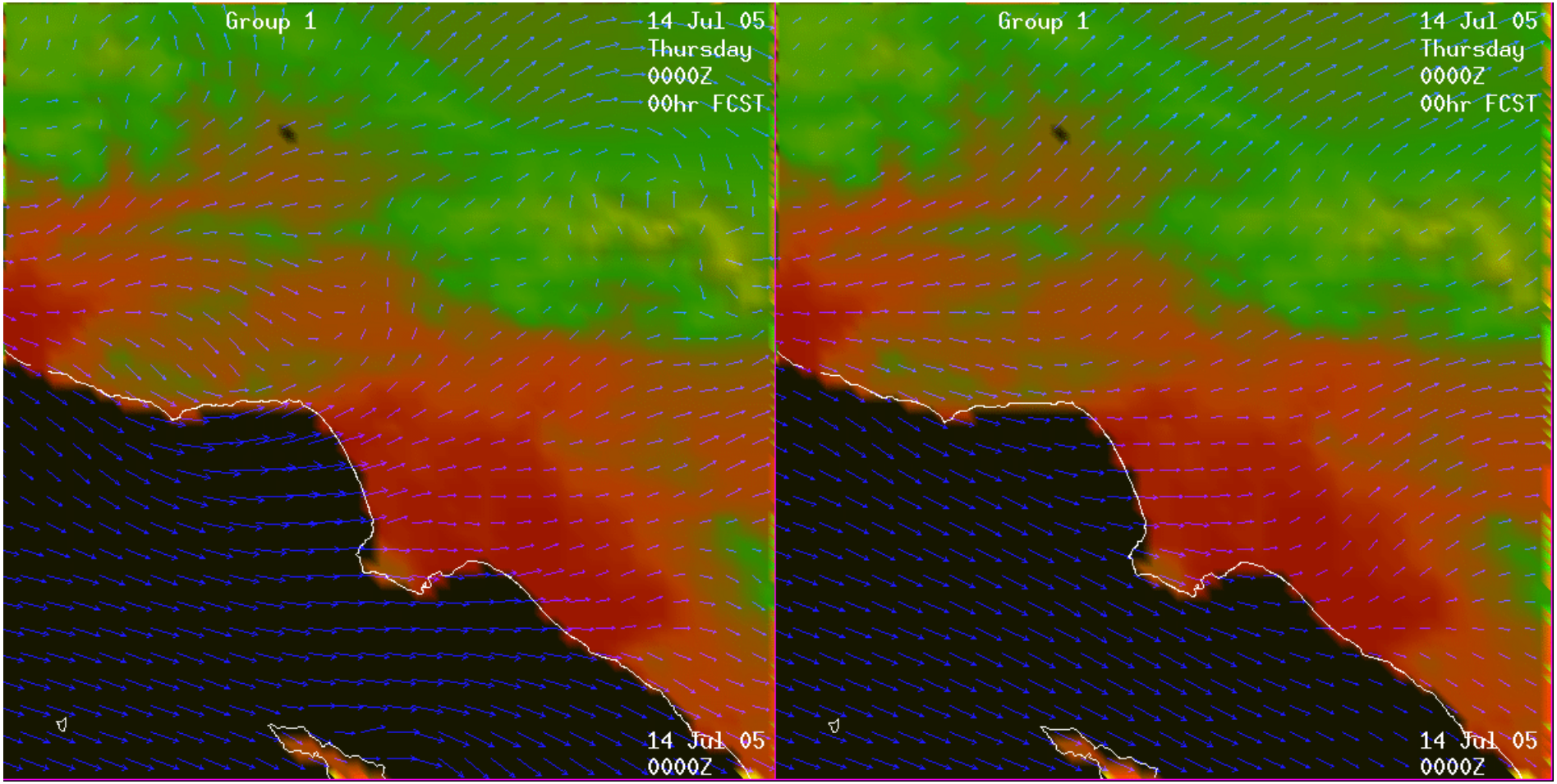
Wind Direction July 14-17

White, Measured
Red: Aerospace cycled
Green: AQMD, nofdda
Blue: AQMD, fdda

Plots generated 06 June 07



Low-level Wind Flow for Nudged and 3DVAR runs



Nudged Run

Rapidly Cycled 3DVAR Run

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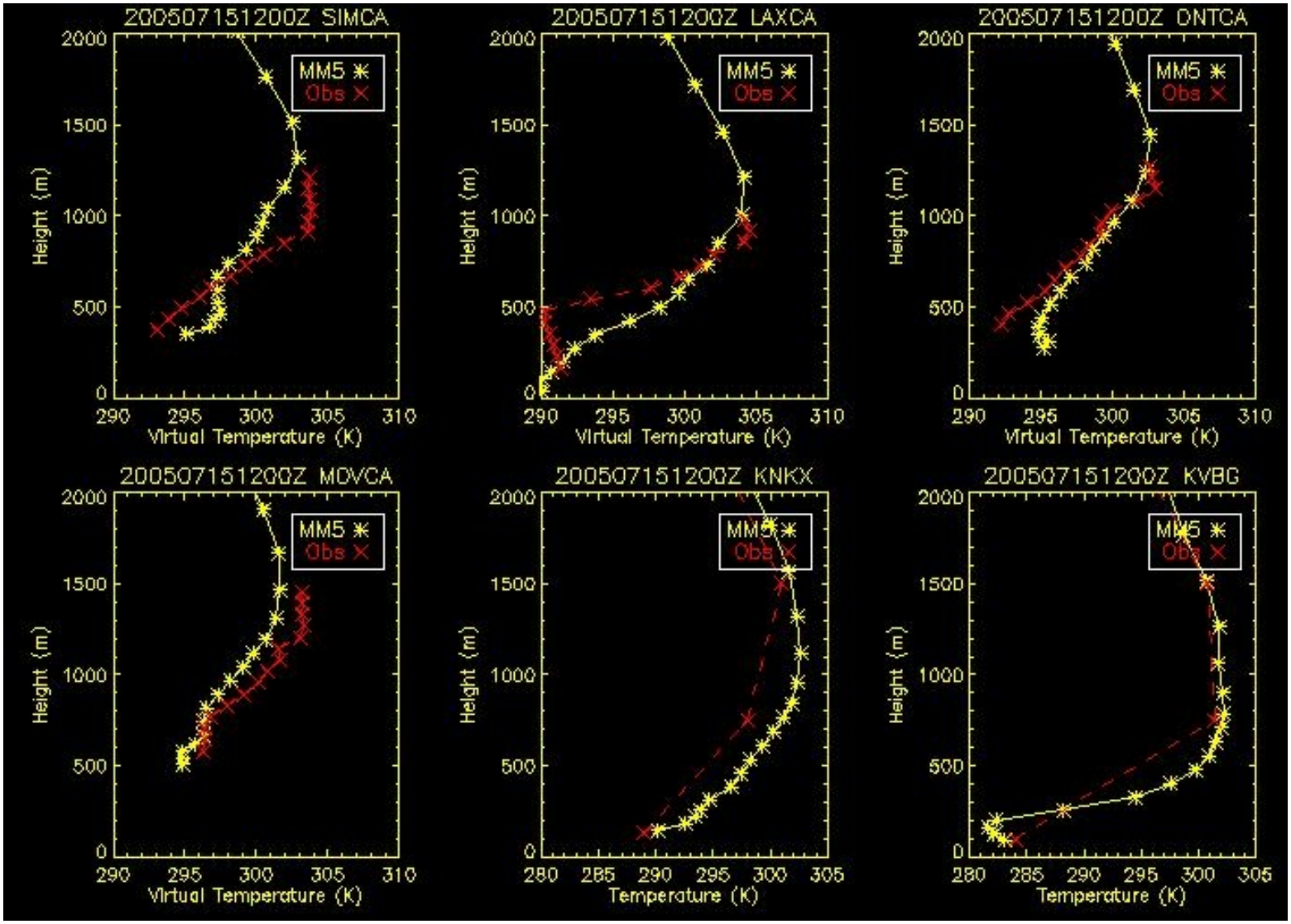
Summary

- Performance of the 3DVAR/MM5 is comparable to the Nudged Runs though significant differences exist in the low-level wind field
- Spurious gravity wave activity indicated in both simulations but it appears to be worst in the 3DVAR/MM5 case
- Full cycling performance could be improved with the addition of a noise control mechanism to 3DVAR
- A number of improvements are in WRF Var or planned for WRF Var that will further improve the performance of a rapidly updating 3DVAR system

Current and Planned Modeling Activities