Meteorological Modeling for CCOS

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Historical Review

- MM5/CAMx and MM5/CMAQ simulations produce too low of ozone in the Central Valley
  - True for July-Aug 2004 and Sept 2004 IOP's
  - FDDA makes some differences at individual sites, but no significant overall change to low ozone bias
  - Changes to MM5 parameterizations do not significantly alter the ozone bias
- Significant improvements in the ozone bias were found by:
  - Increasing VOC emissions by a factor of 3 (Tesche et al.)
  - Reducing model wind speeds by 50% (Tonneson)
- MM5-Calmet/CAMx hybrid reduces low ozone bias to an acceptable level for July-August IOP, but not September (Bruce Jackson)

Ozone bias

MM5

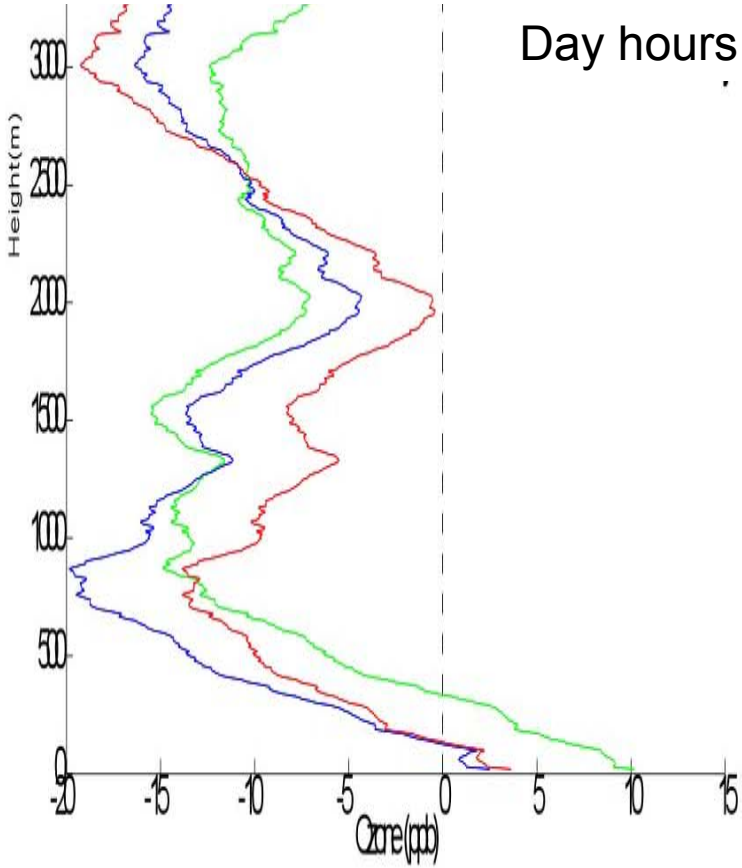
MM5-FDDA

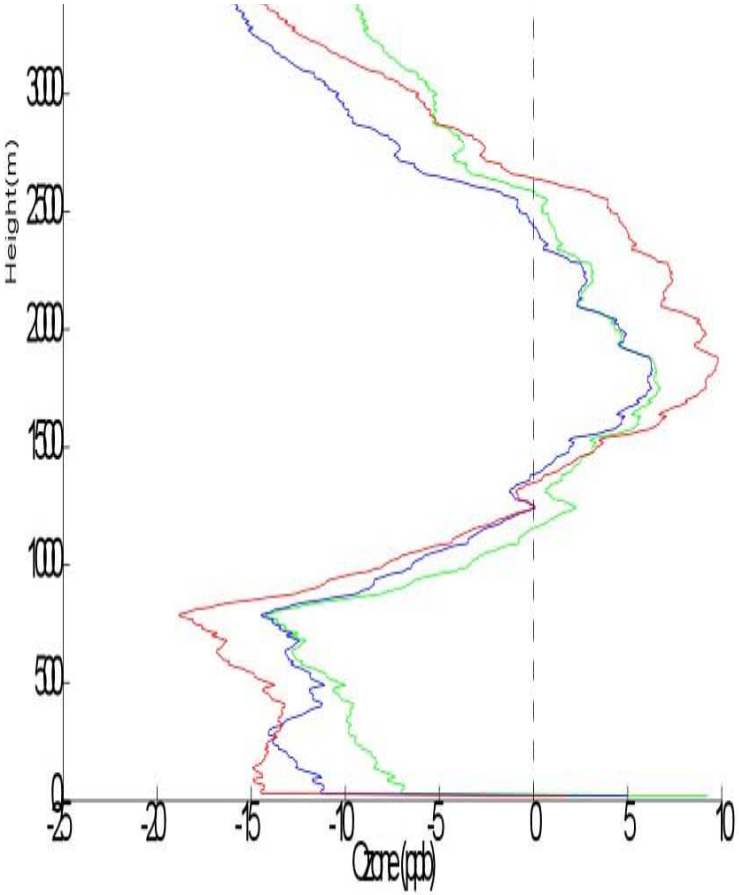
Hybrid

Parlier

Granite Bay

Day hours





Outline

- Comparison of MM5 and hybrid meteorological fields
- Mass Conservation/Off-line vs. On-line Chemistry
- New Meteorological Simulations
  - Time-Averaged MM5 Simulations
  - 1km MM5
  - WRF simulation

MM5 and Hybrid Comparison

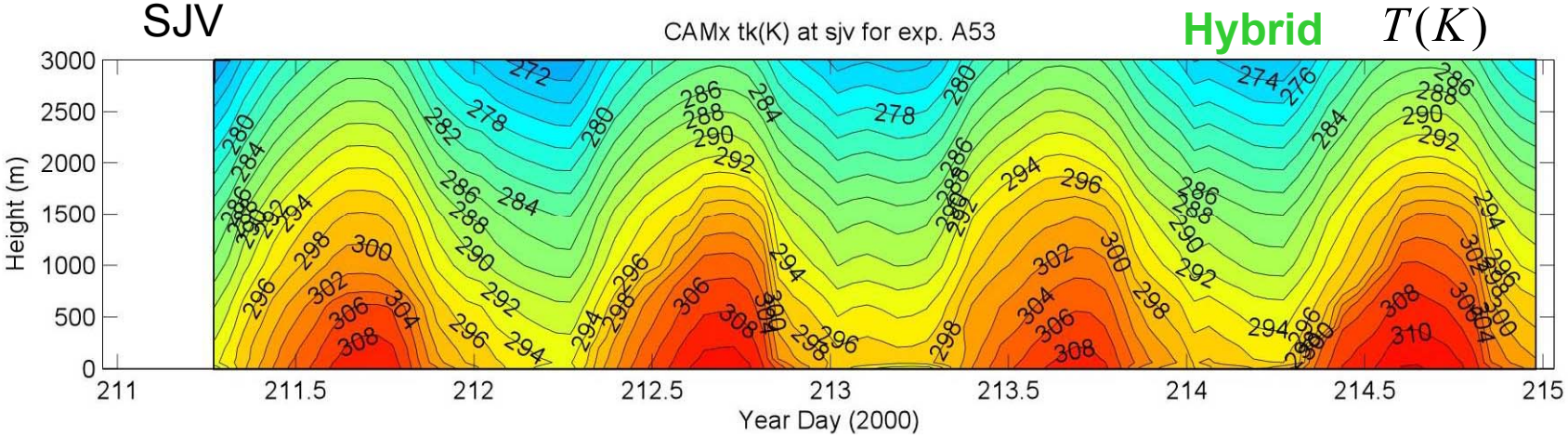
- Temperature
- Moisture
- PBL Depths/Kz
- Winds

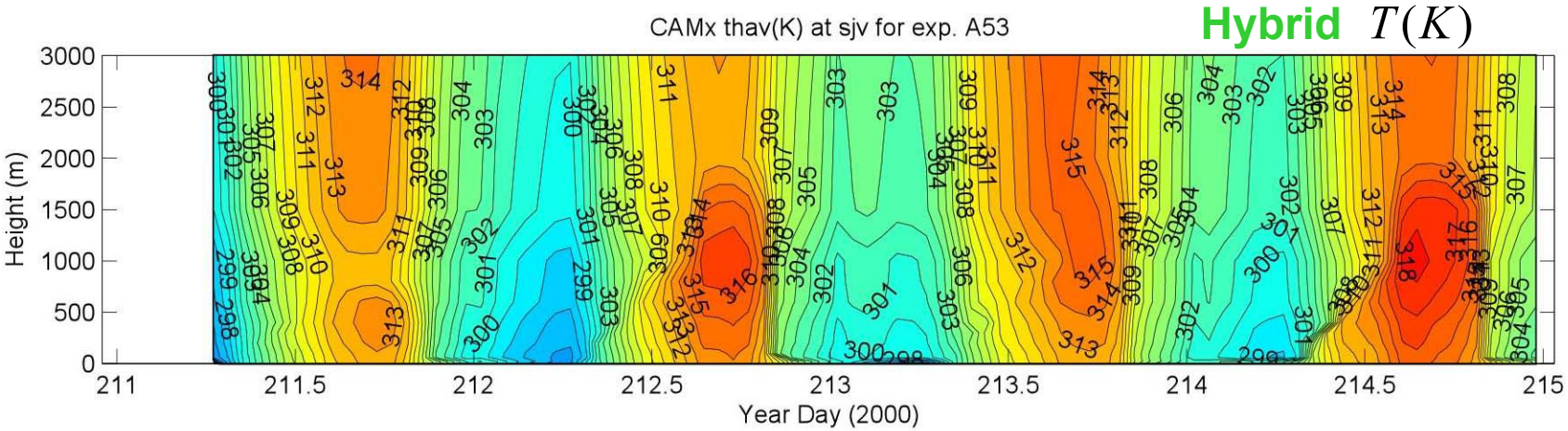
MM5/Hybrid wind and temperature comparison

- Observations:
  - winds and RASS virtual temperatures from 24 wind profiler sites
  - co-located surface (2m or 10m) winds and temperatures

- Observations and MM5 profile data are linearly interpolated to hybrid vertical levels

SJV


CAMx tk(K) at sjv for exp. A53
Hybrid $T(K)$
Height (m)
Year Day (2000)


CAMx thav(K) at sjv for exp. A53
Hybrid $T(K)$
Height (m)
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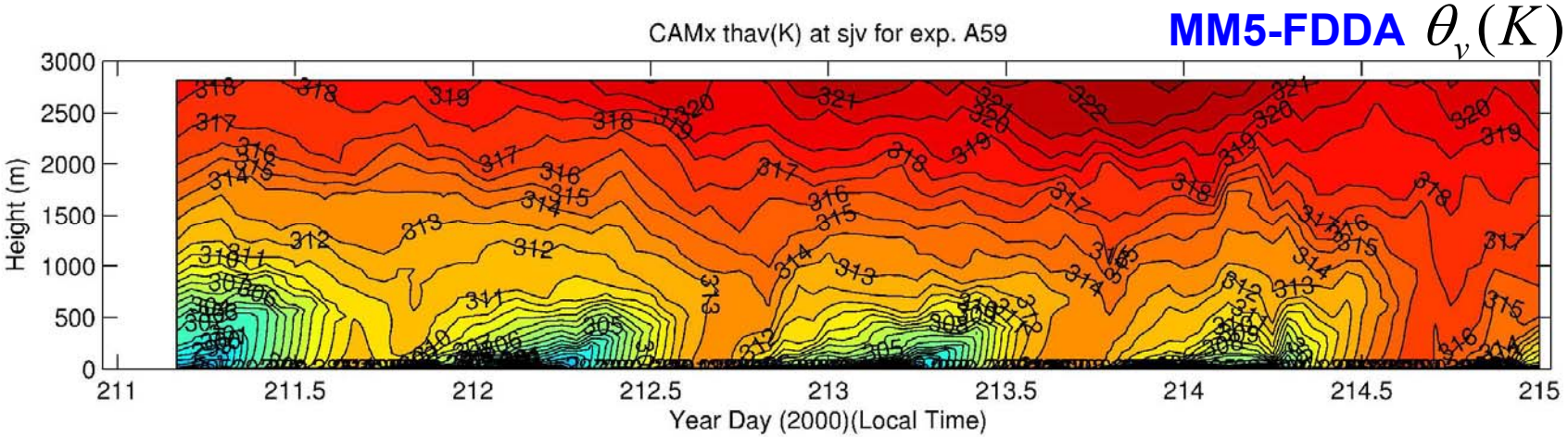
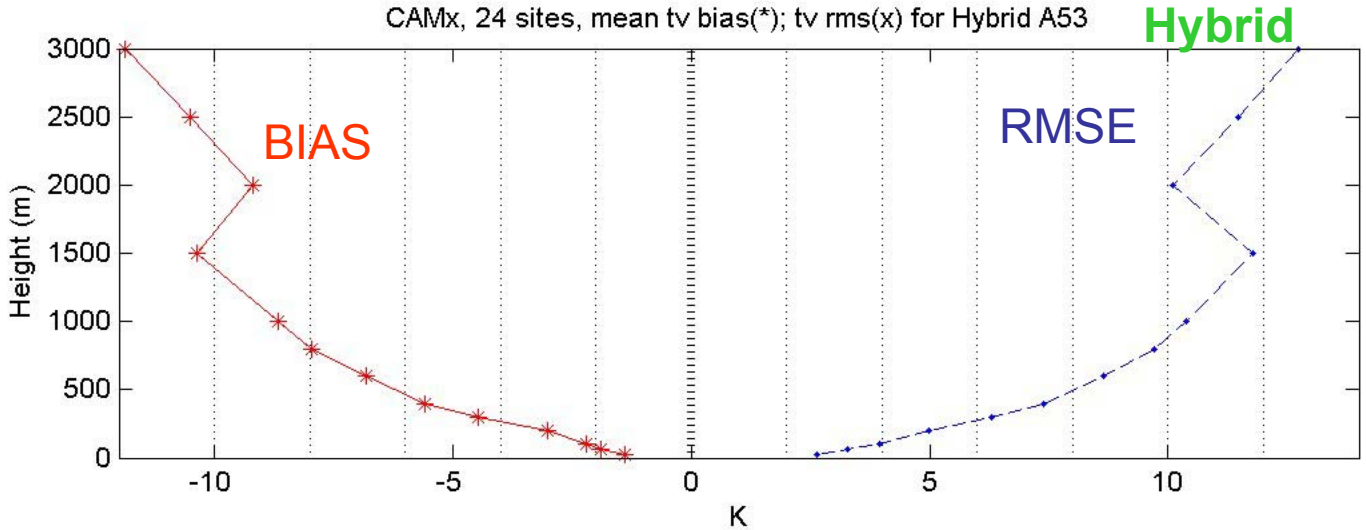
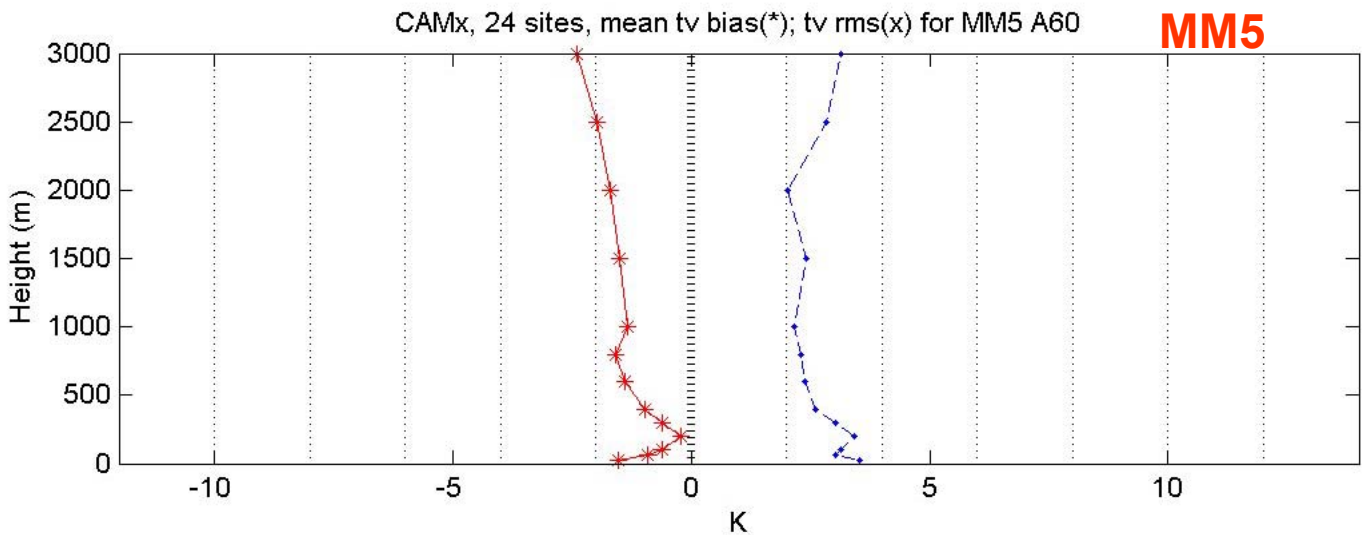
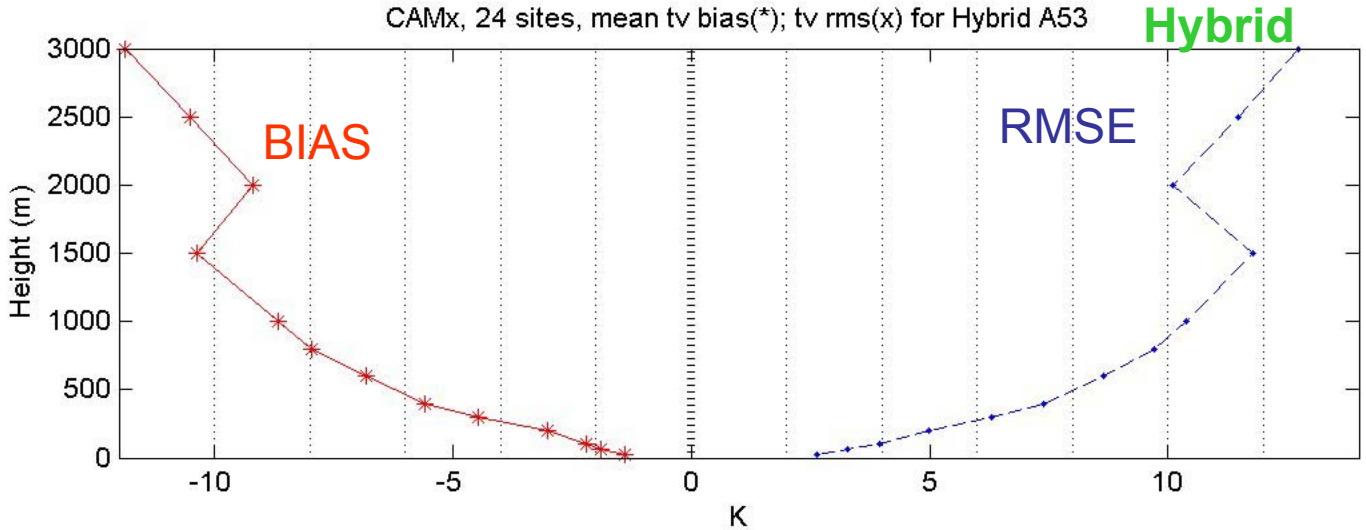

CAMx thav(K) at sjv for exp. A59
MM5-FDDA $\theta_v(K)$
Height (m)
Year Day (2000)(Local Time)

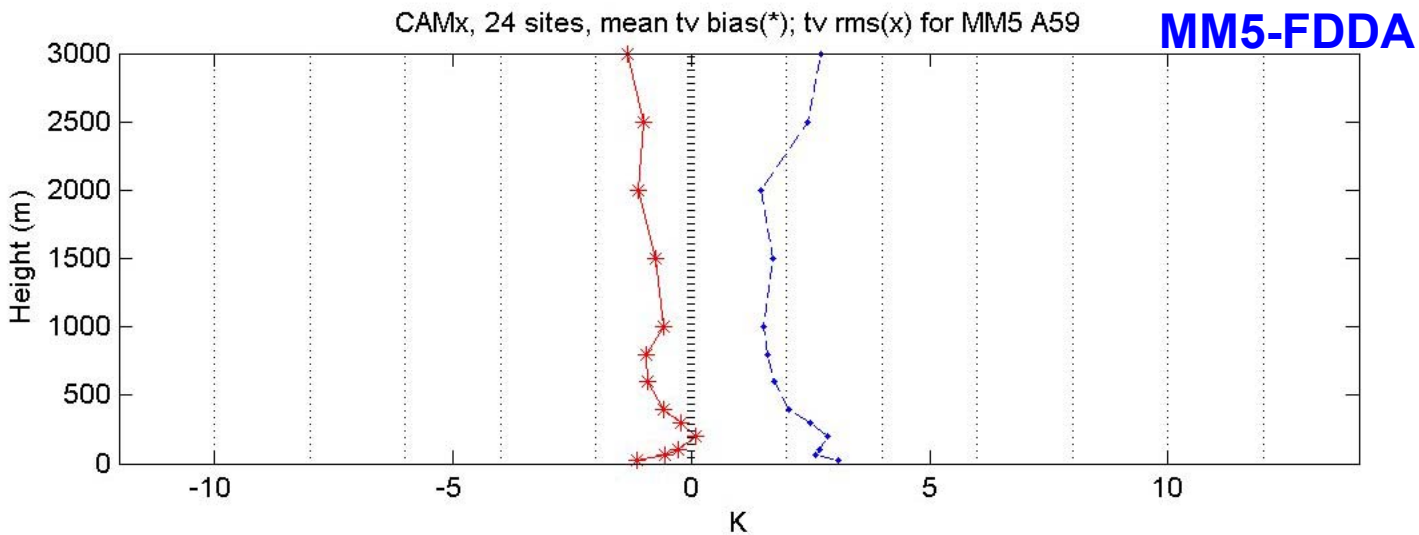
Temperature Errors (K)
All Sites

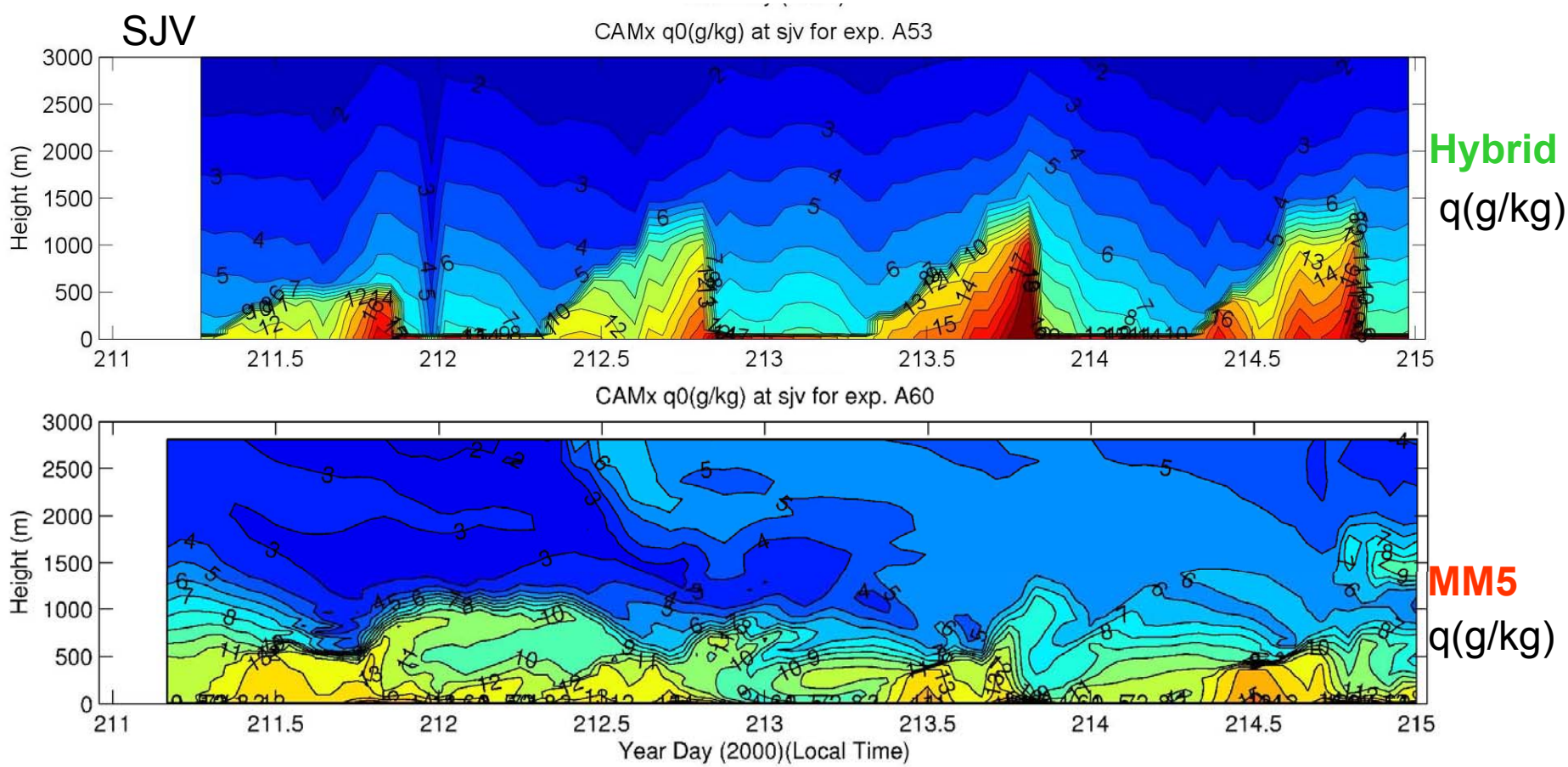


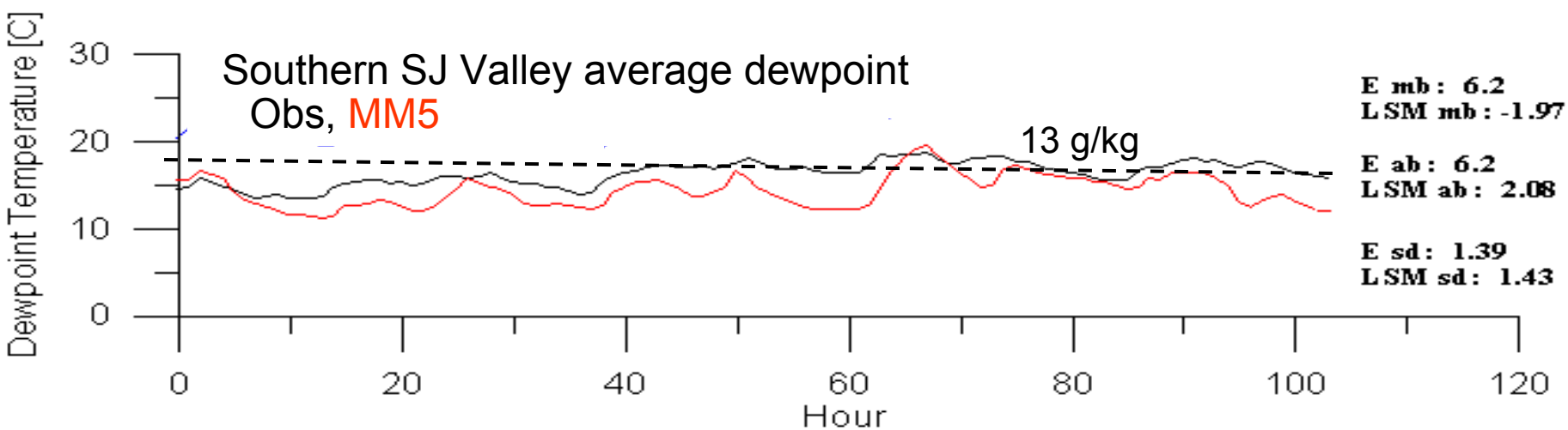


Temperature Bias (K)
All Sites

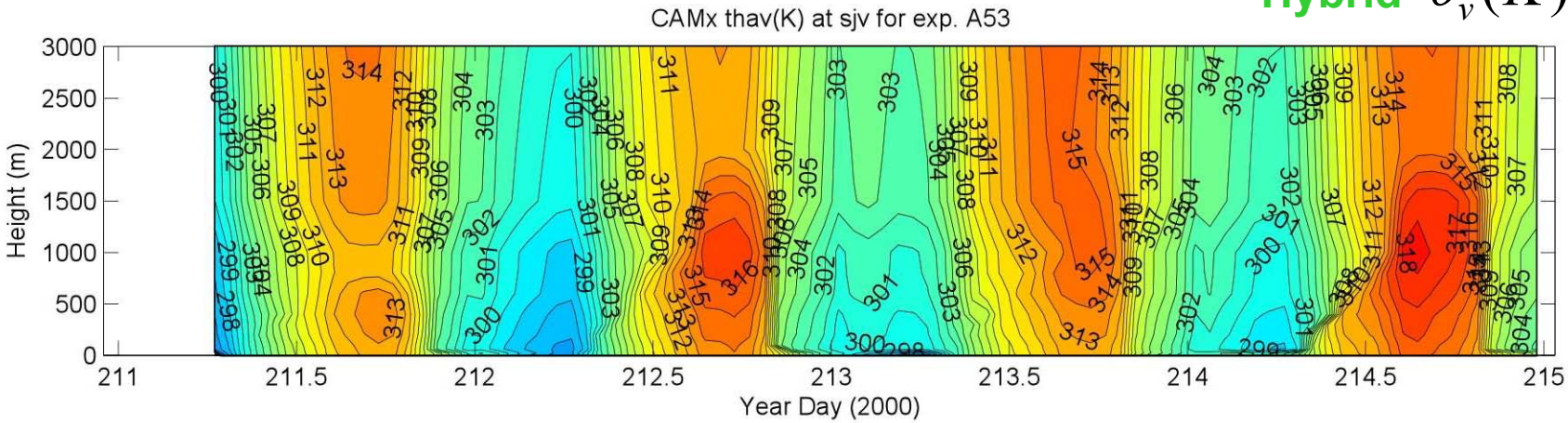




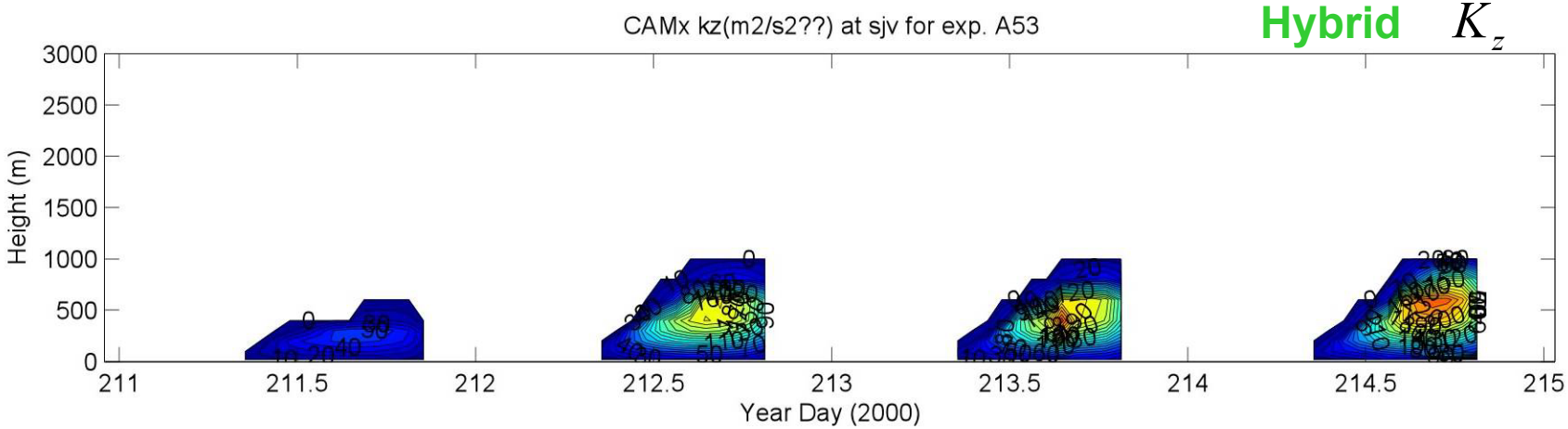

SJV
CAMx q0(g/kg) at sjv for exp. A53
Height (m)
Hybrid
q(g/kg)
CAMx q0(g/kg) at sjv for exp. A60
MM5
q(g/kg)
Year Day (2000)(Local Time)


Southern SJ Valley average dewpoint
Obs, MM5
13 g/kg
E mb: 6.2
LSM mb: -1.97
E ab: 6.2
LSM ab: 2.08
E sd: 1.39
LSM sd: 1.43
Dewpoint Temperature [C]
Hour

Hybrid $\theta_v(K)$

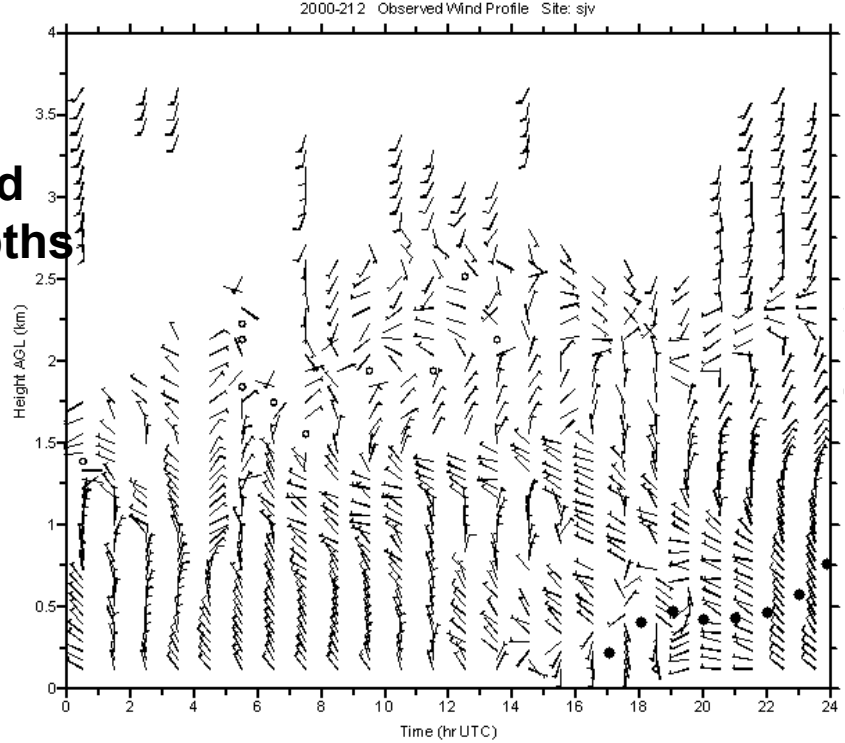


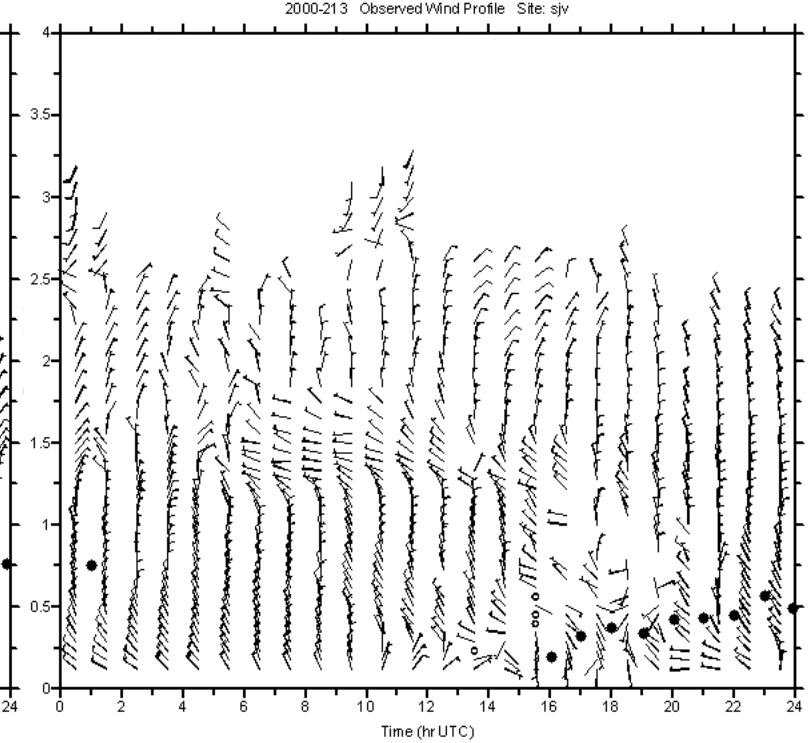
Hybrid K_z

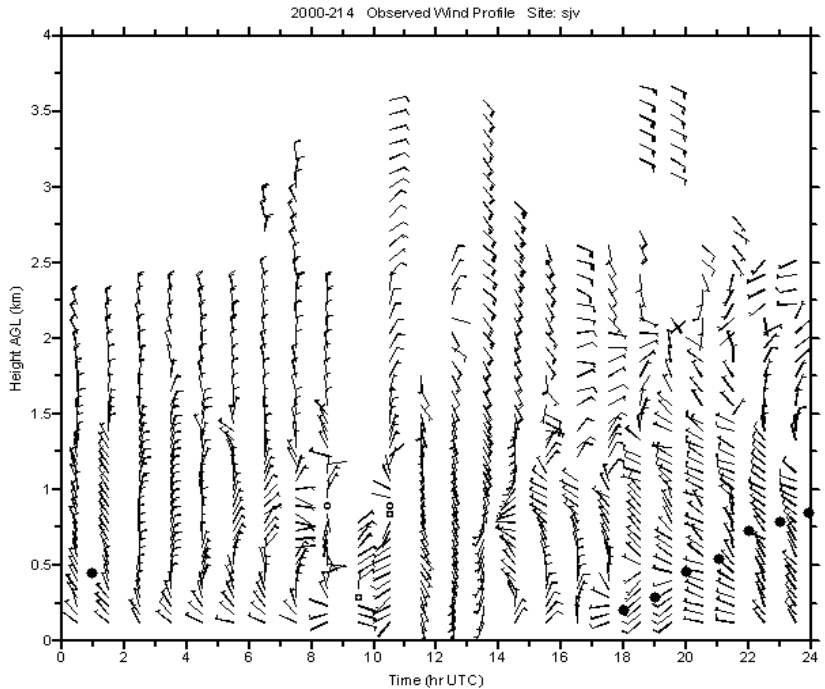


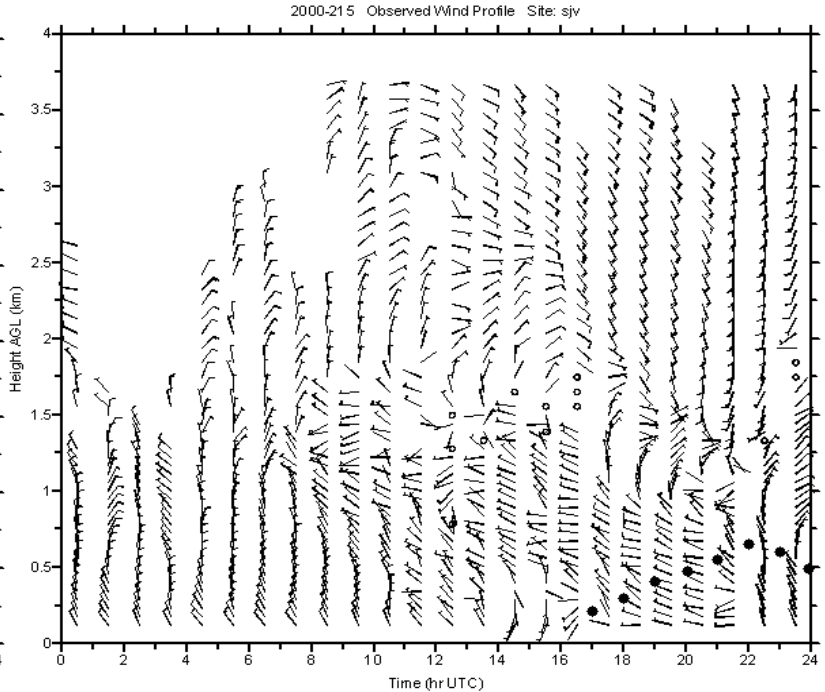
SJV

Observed PBL Depths



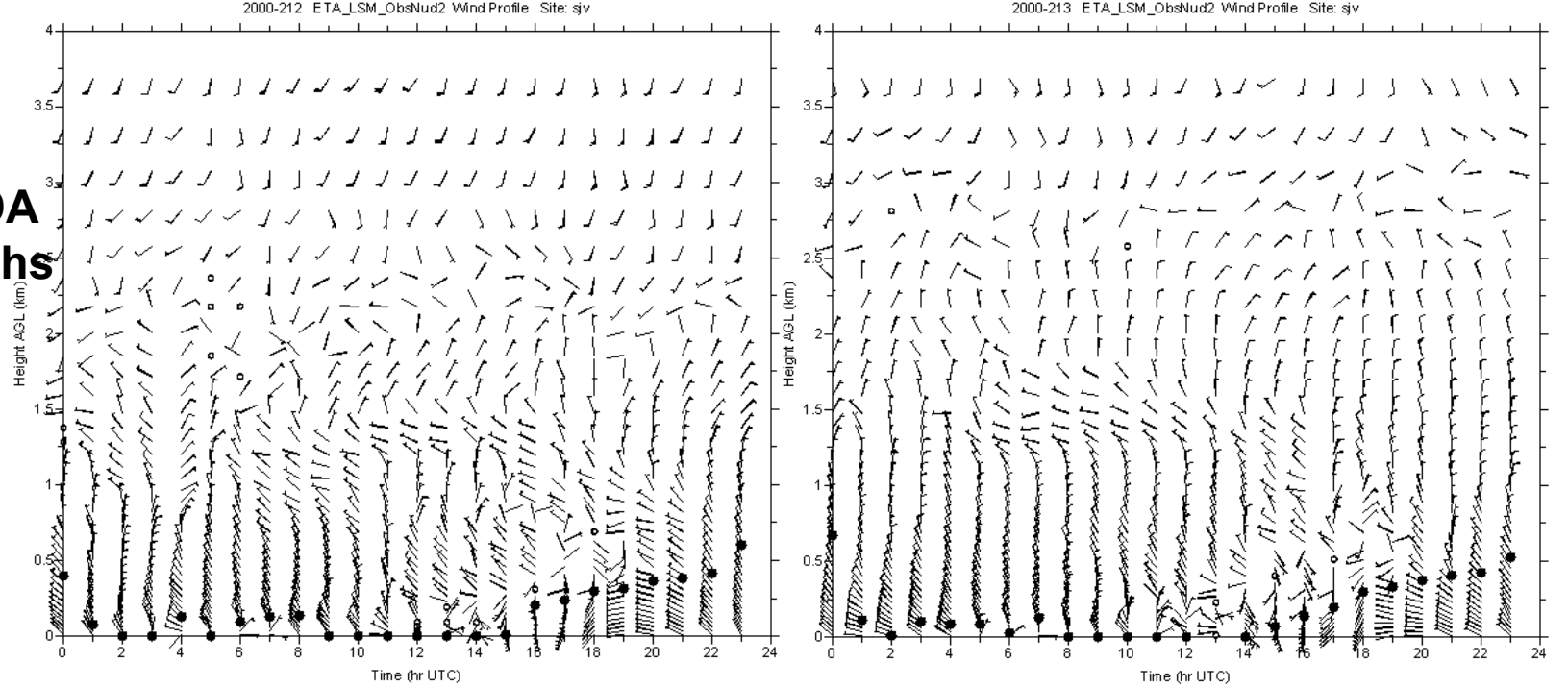


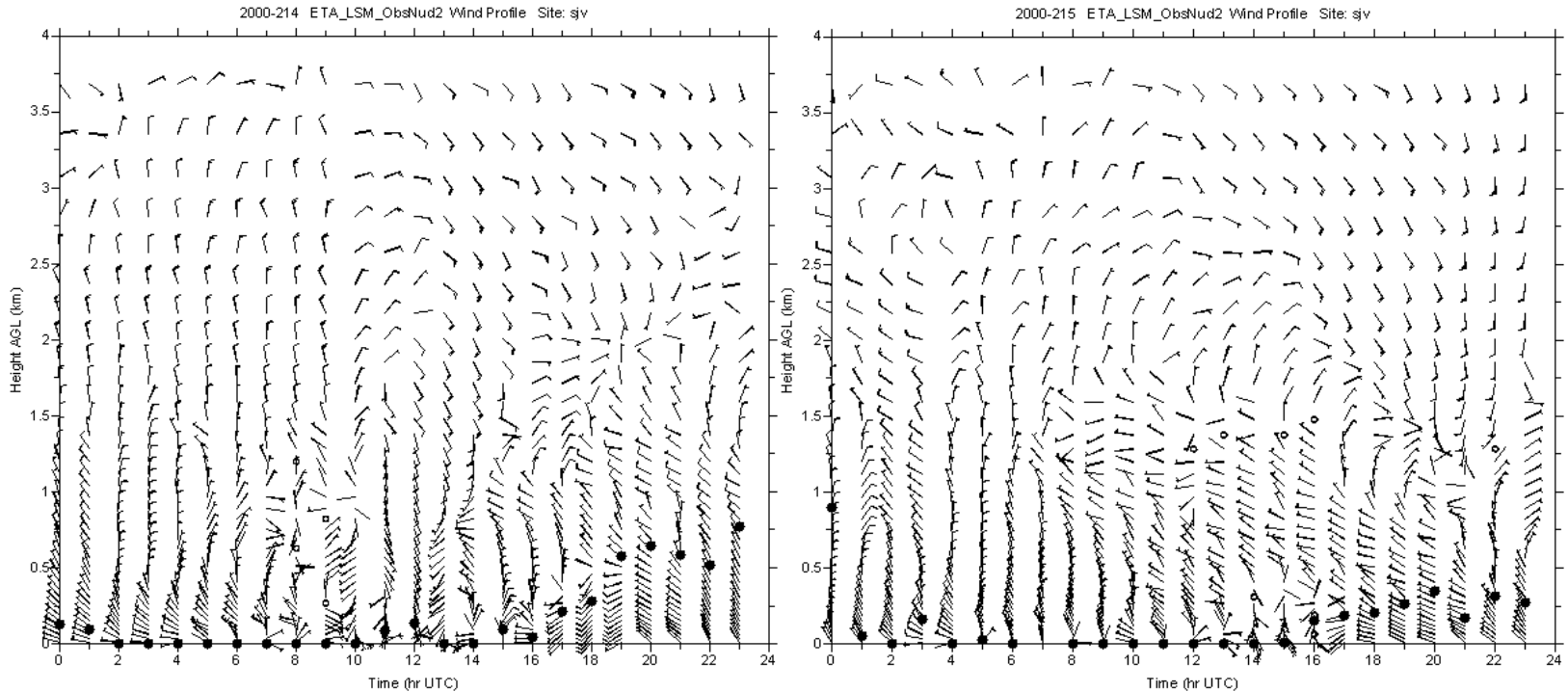




SJV

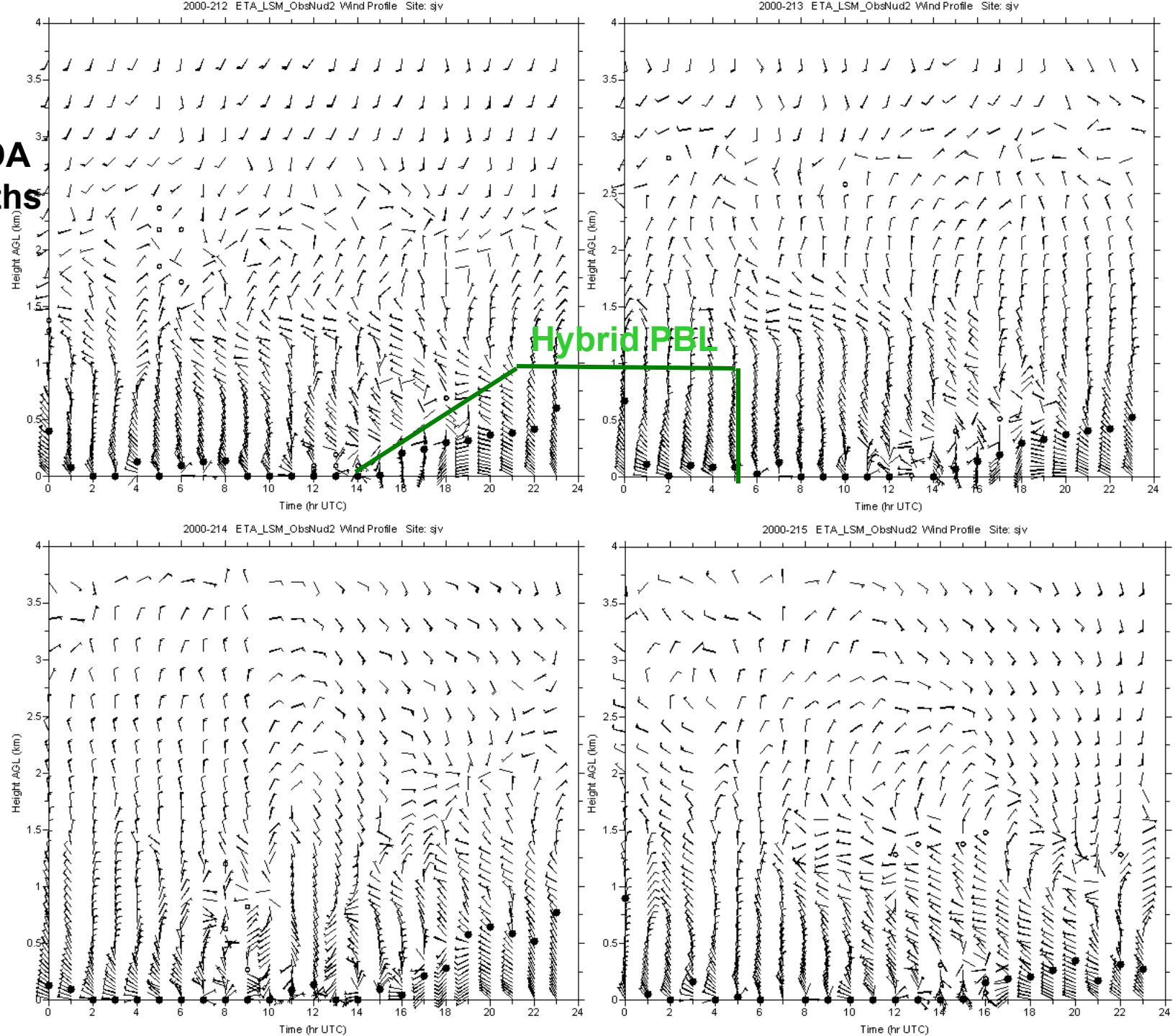
MM5-FDDA PBL Depths





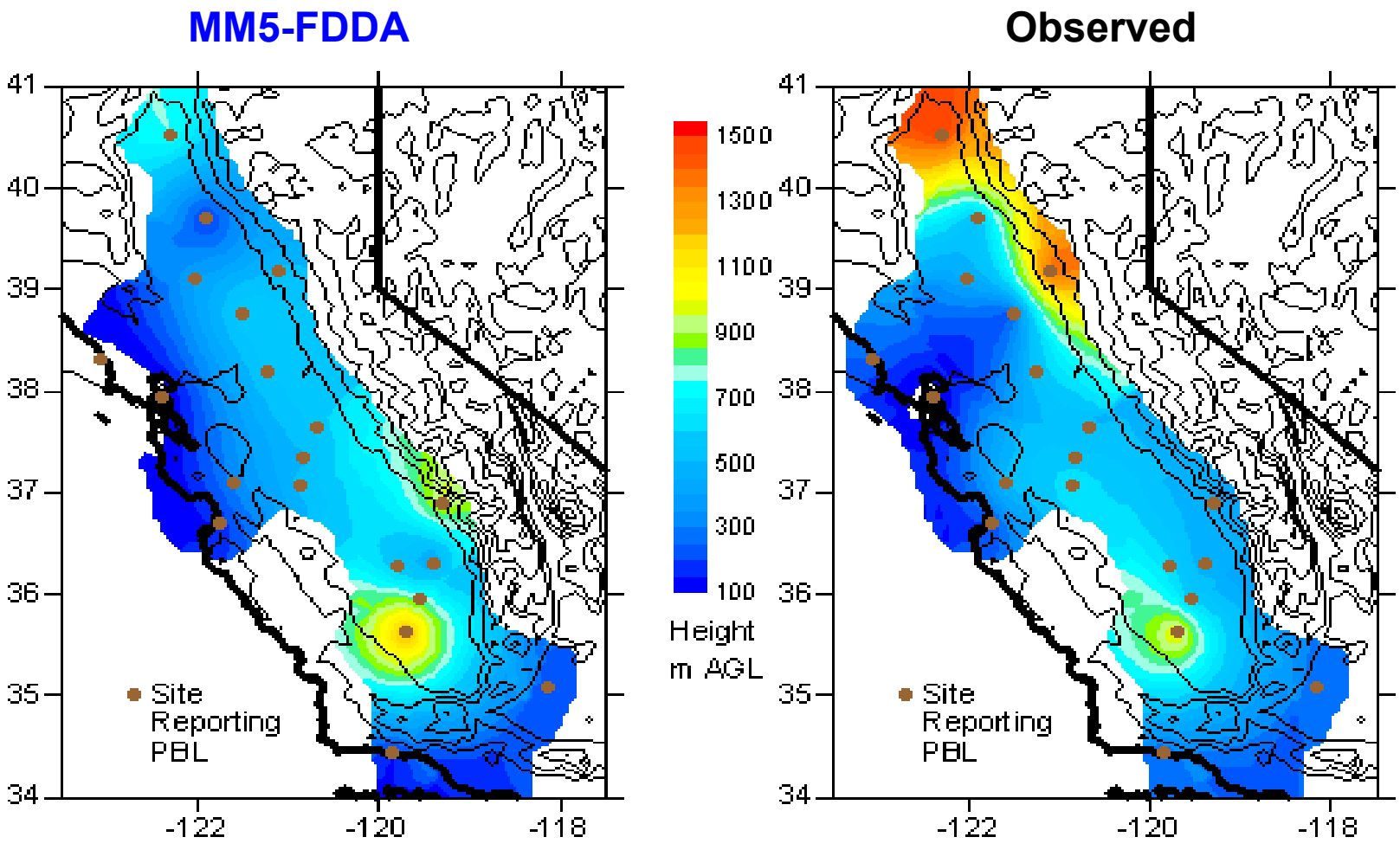
SJV

MM5-FDDA PBL Depths



PBL (m)

JD 212 At time of maximum depth

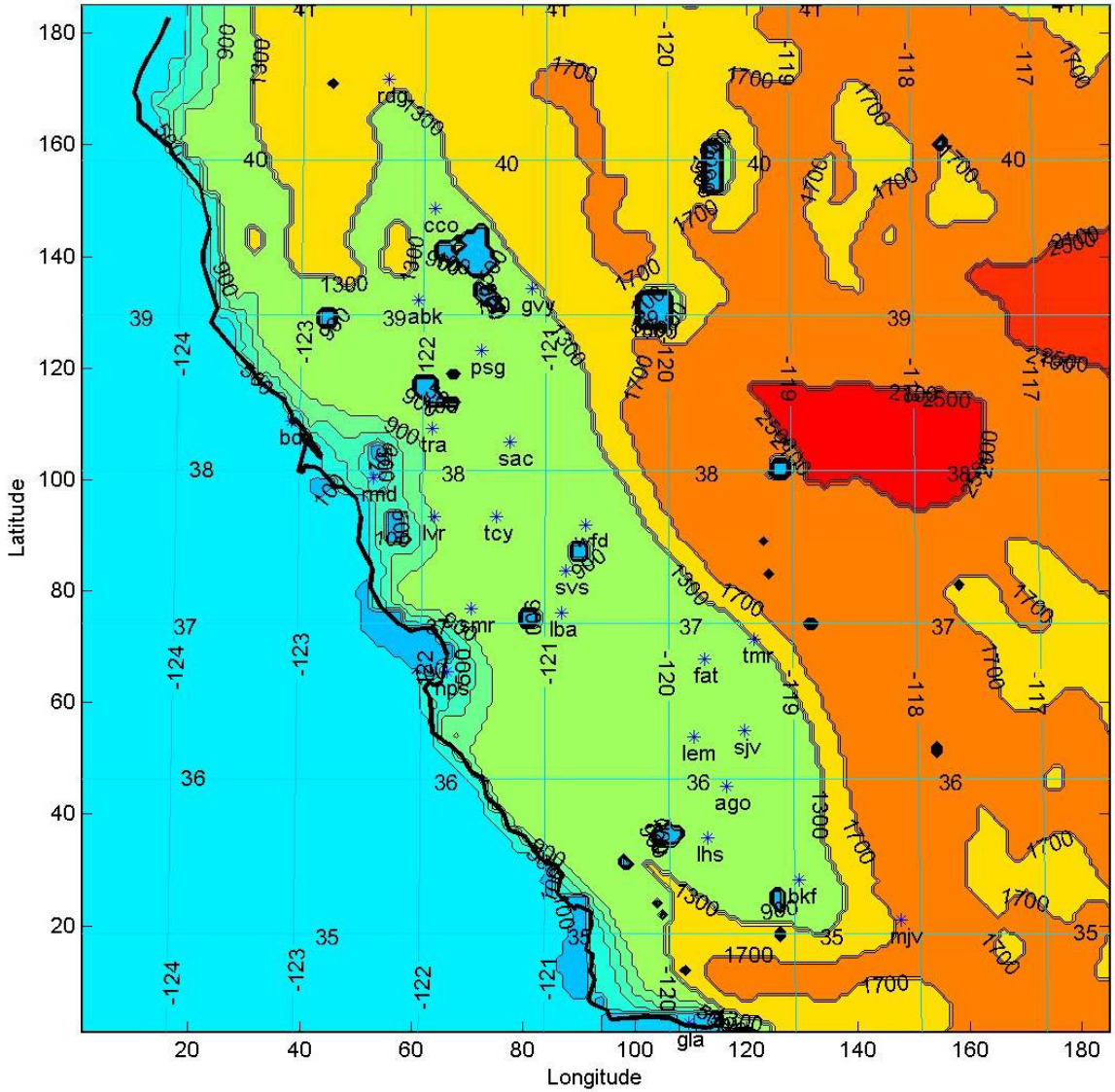


PBL Depth (m)

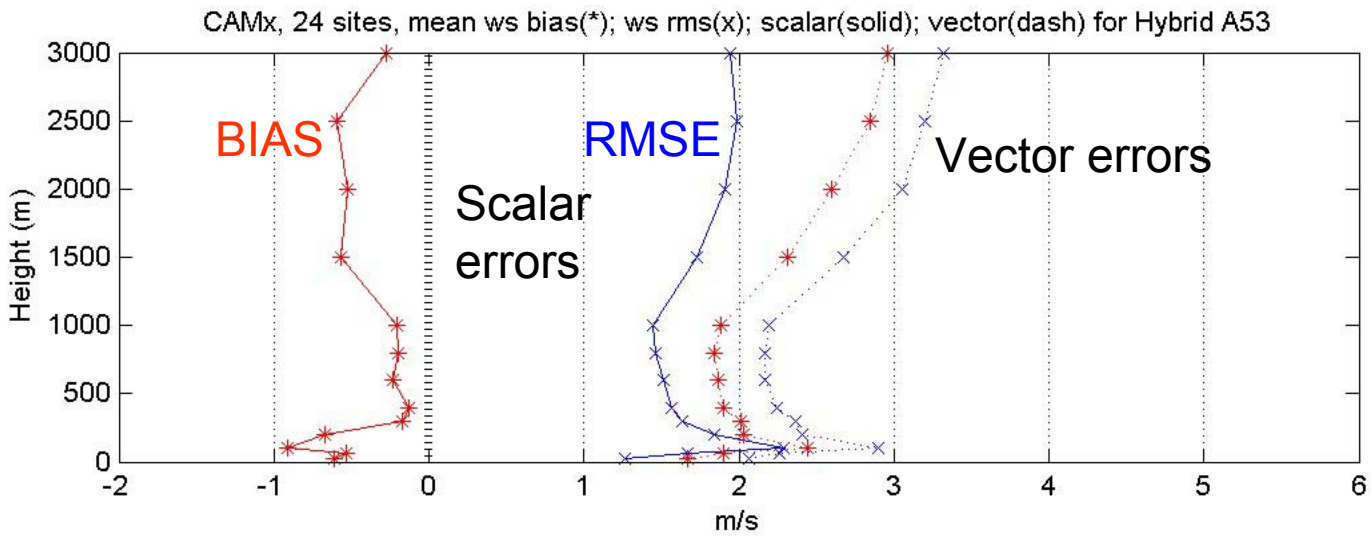
JD 212 At time of maximum depth

Hybrid

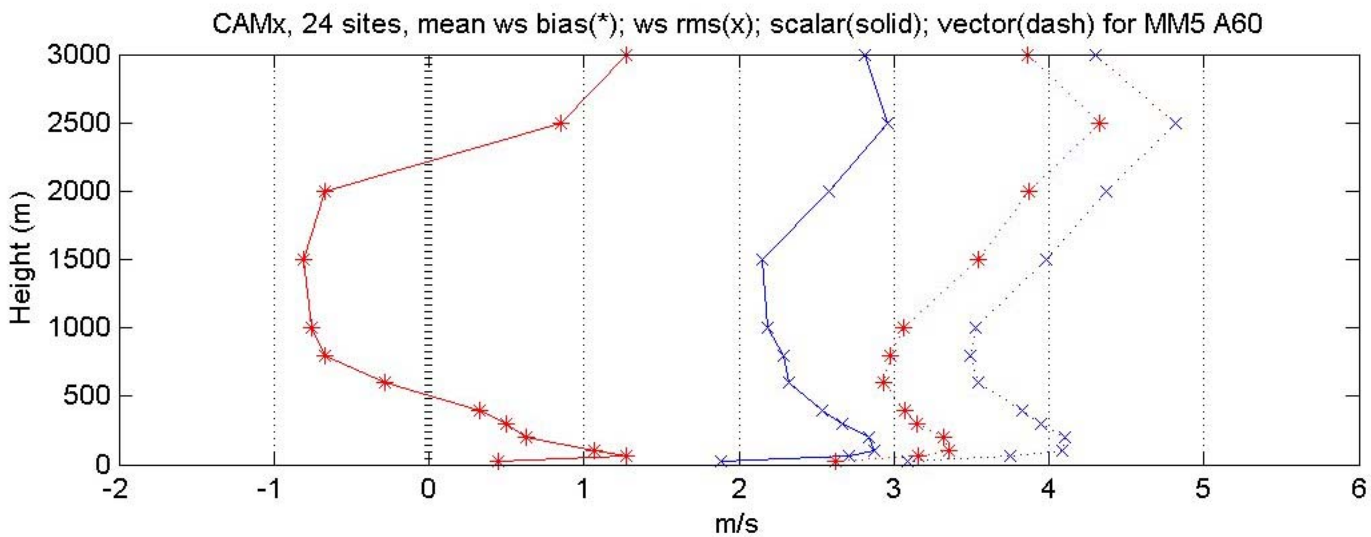
A53 kztop(m) at JD= 212; HR= 19; thresh= 0.2 m2/s2



Wind errors – All Sites

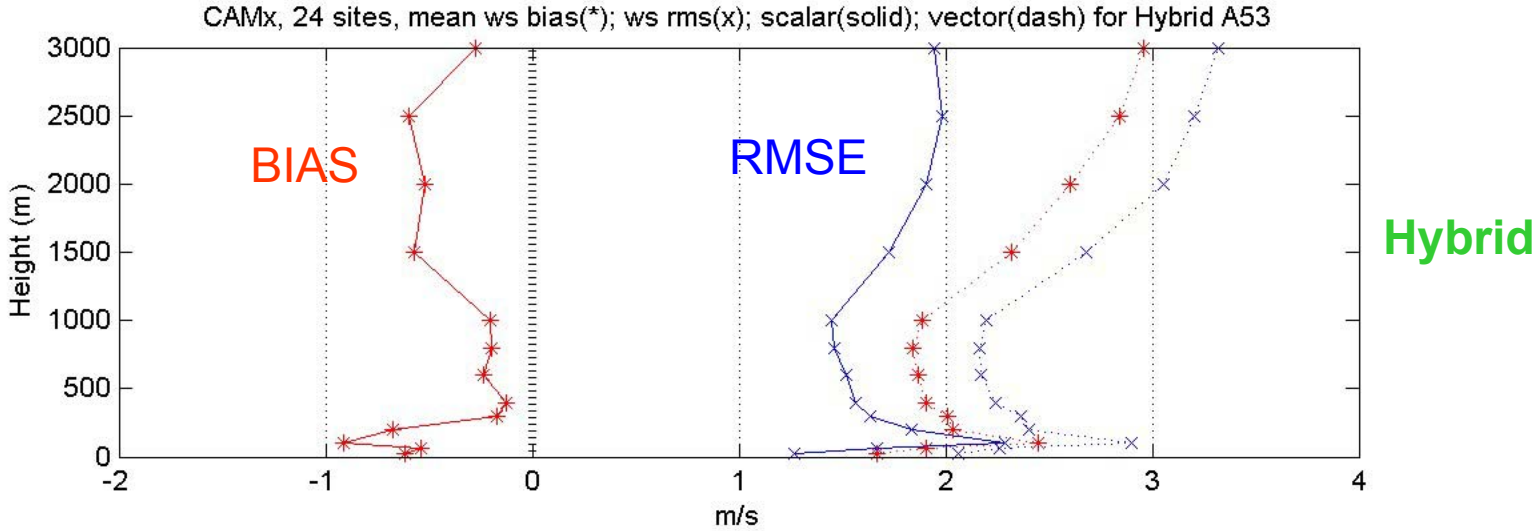


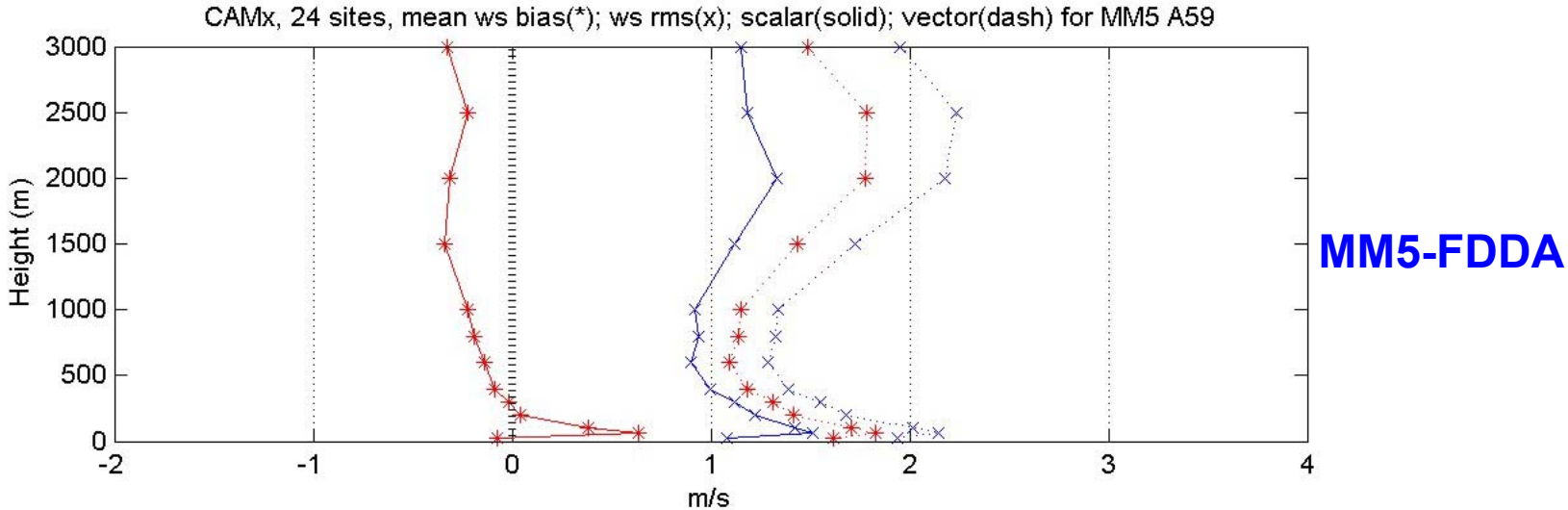
Hybrid



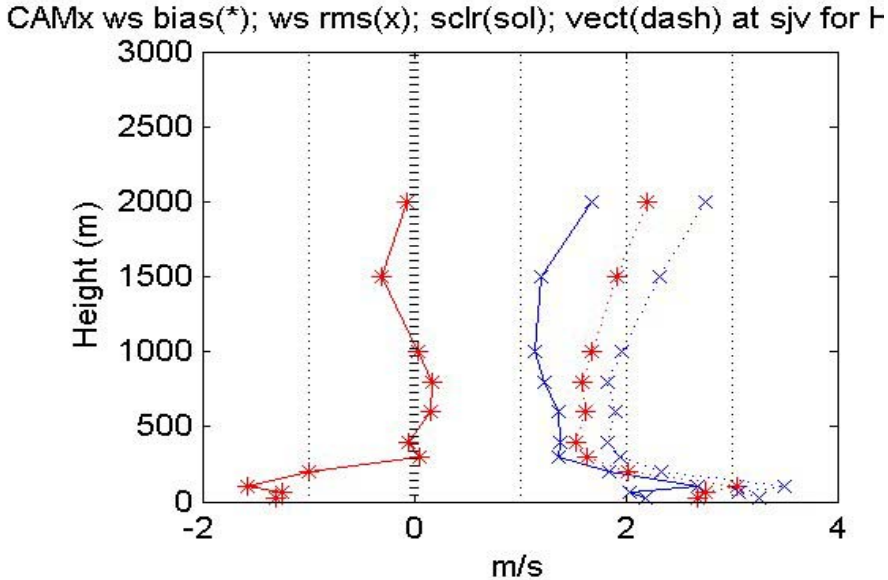
MM5

Wind errors – All Sites

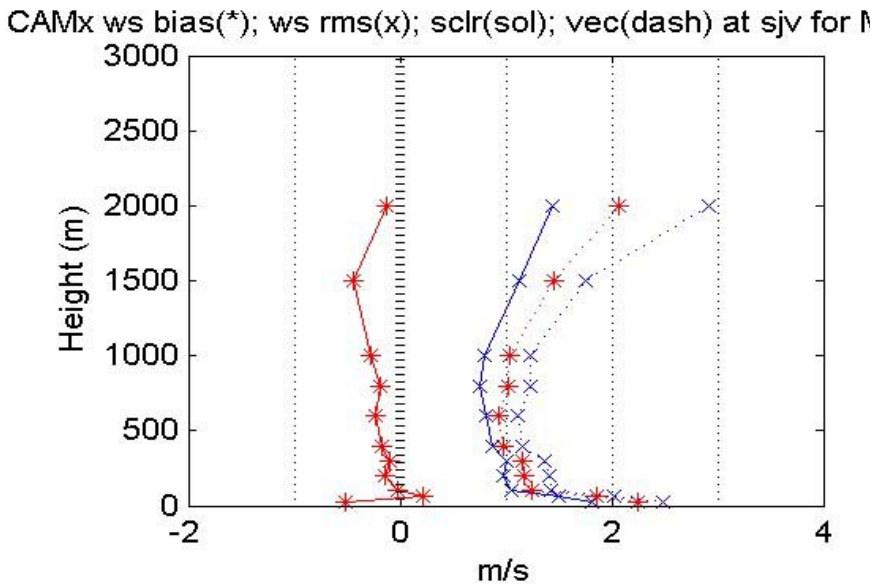




Wind errors – SJV

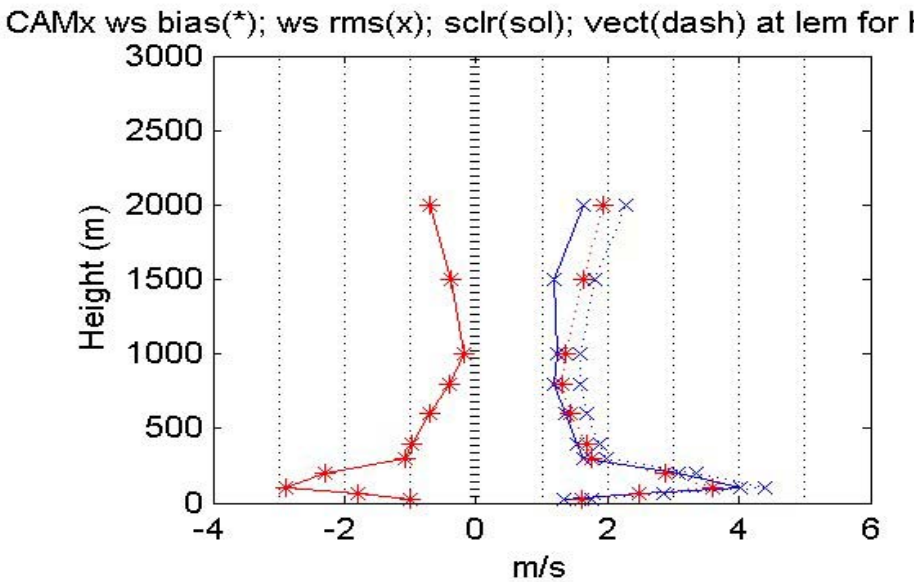


Hybrid

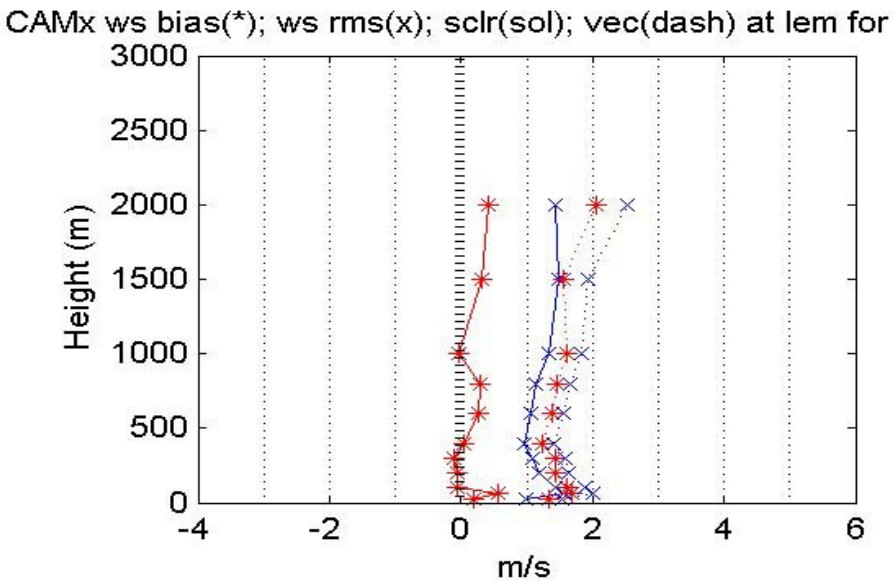


MM5-FDDA

Wind errors – LEM

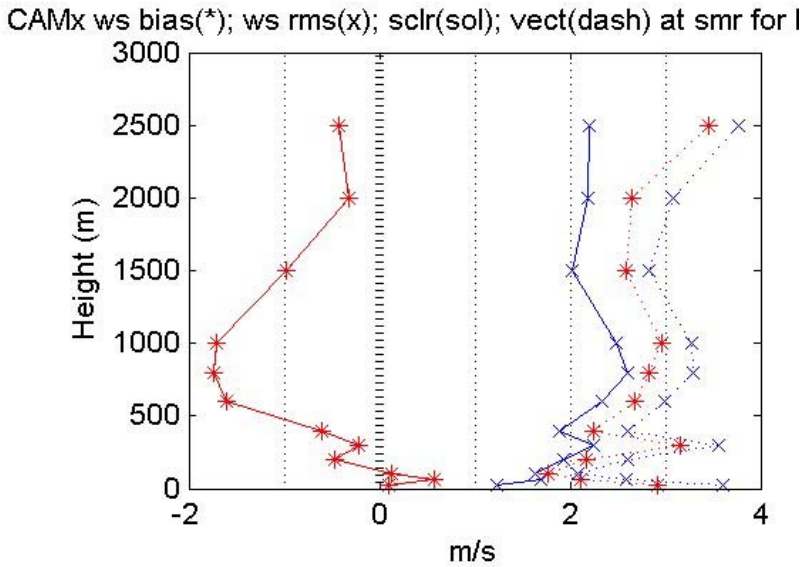


Hybrid

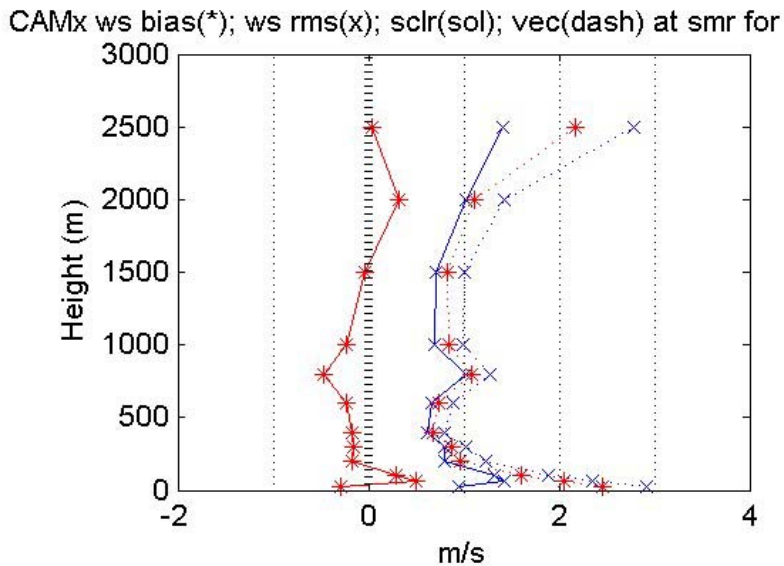


MM5-FDDA

Wind errors – SMR

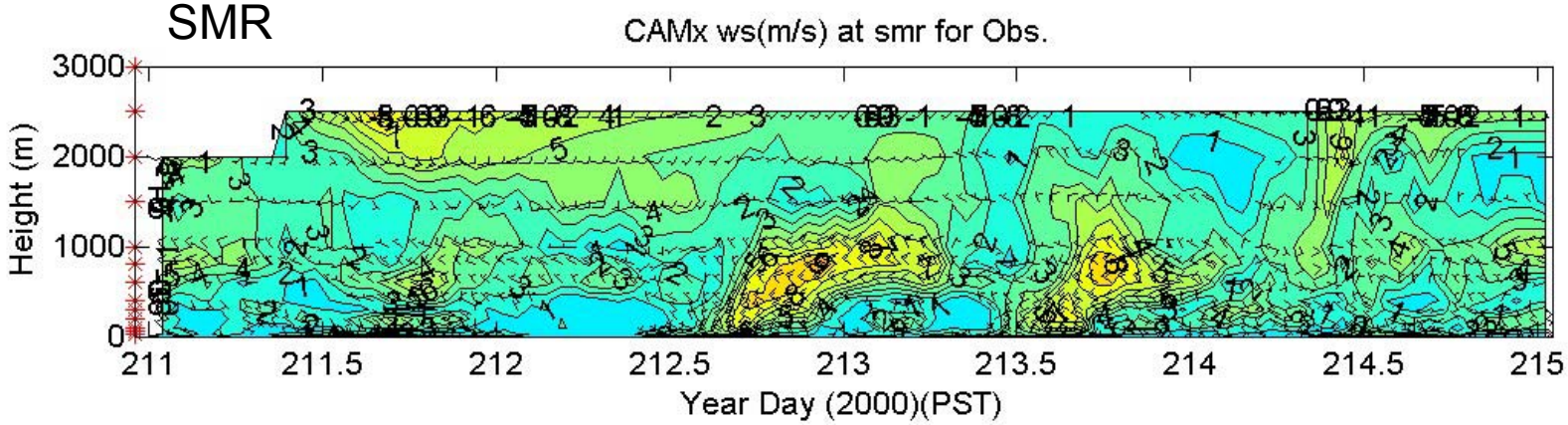


Hybrid

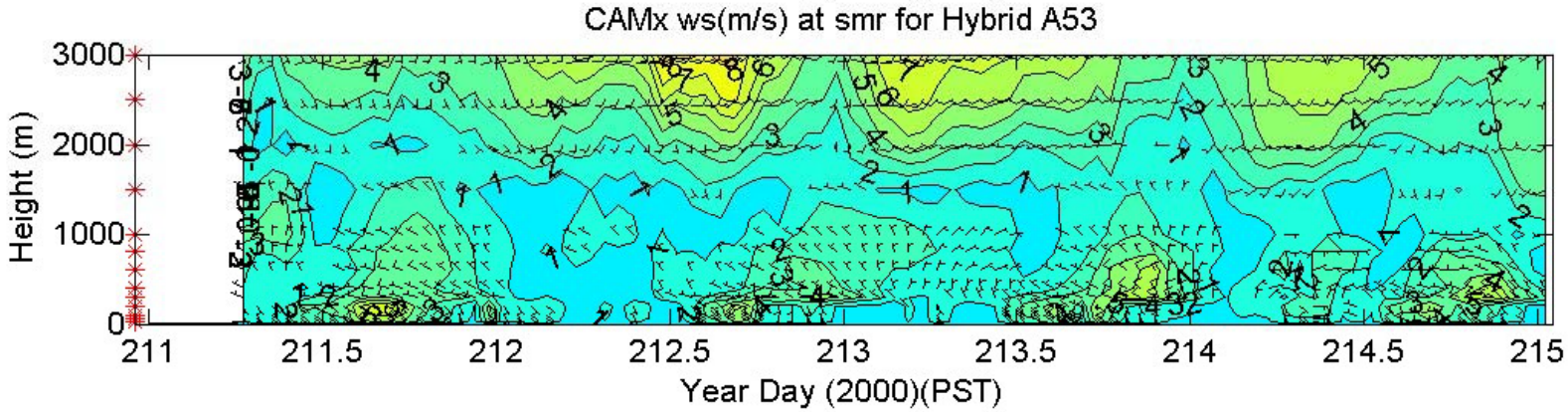


MM5-FDDA

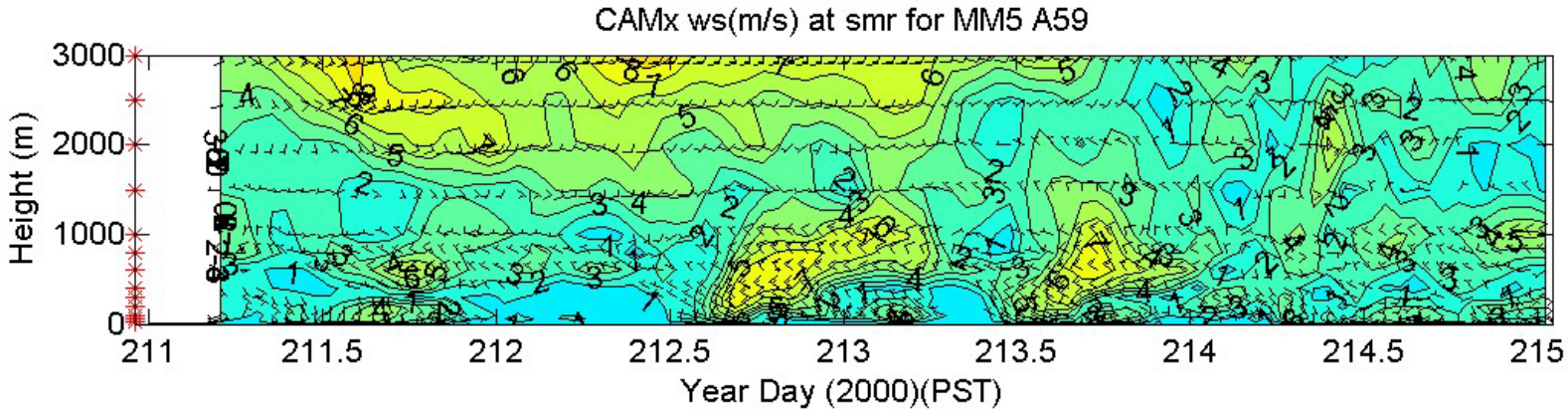
SMR



Obs

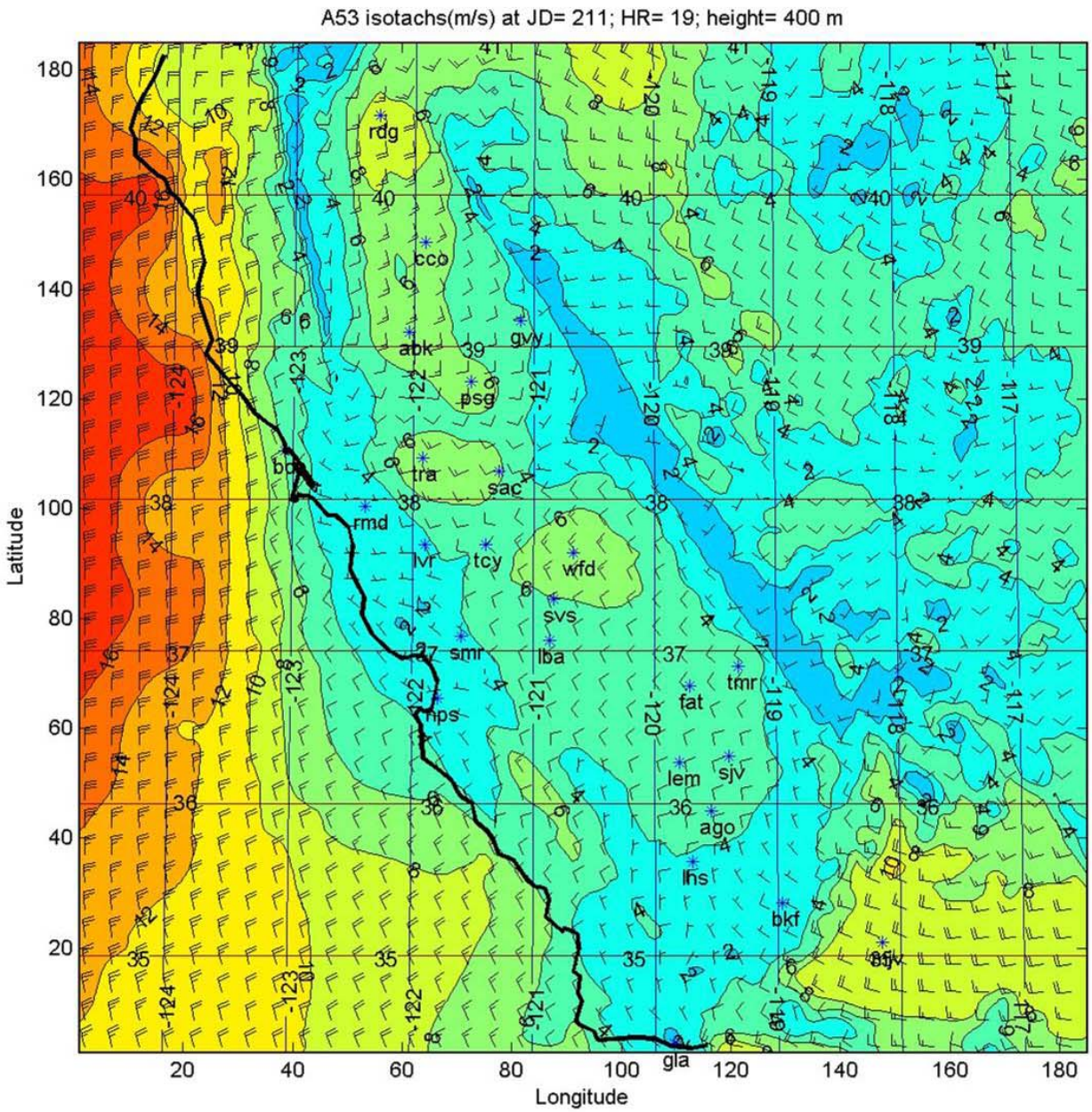


Hybrid



MM5-FDDA

Hybrid wind field JD211 19LST 400m



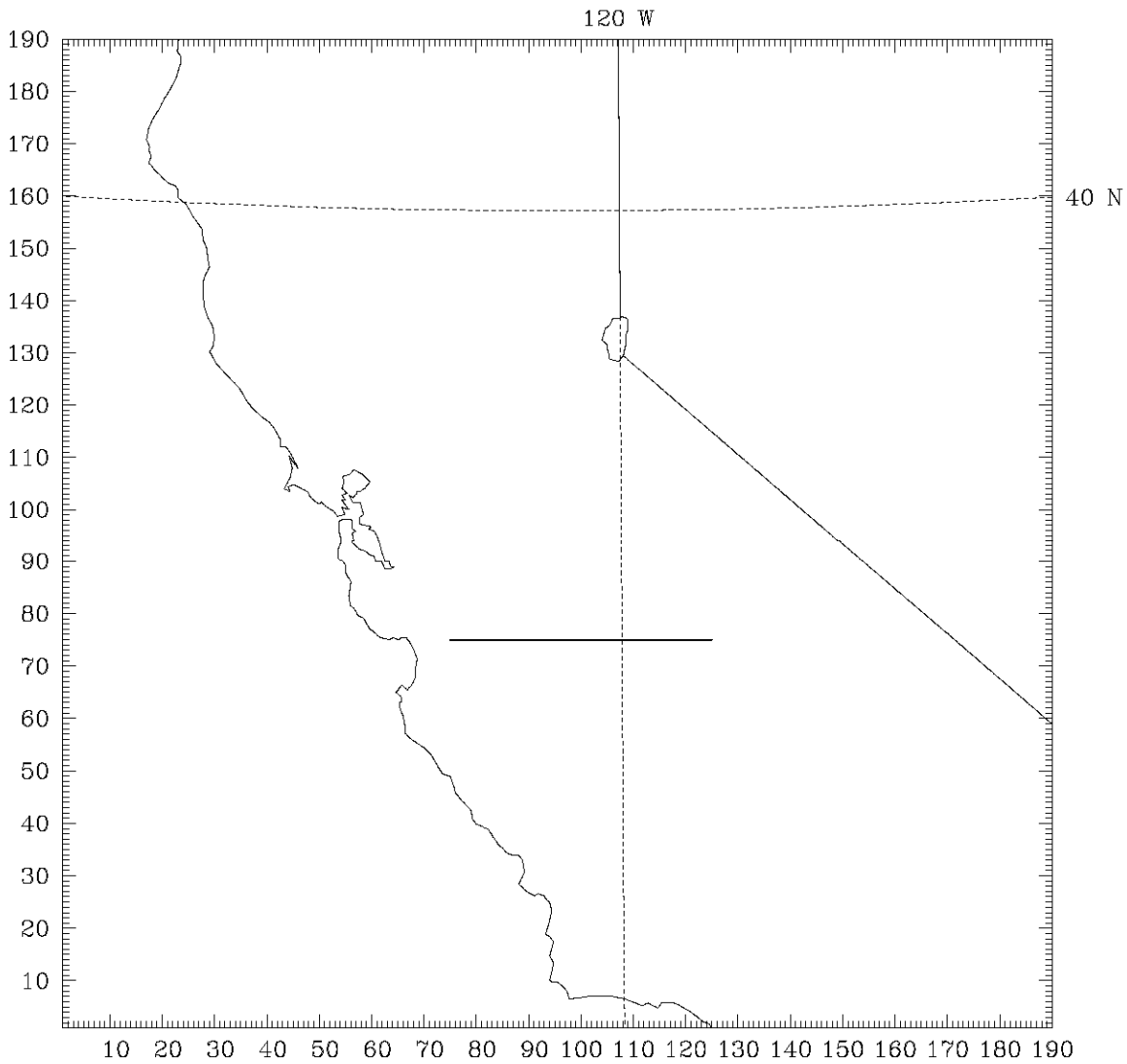
Hybrid – MM5 Differences

- Hybrid temperatures are colder aloft, especially at night
- Hybrid is moister during day, drier at night
- Hybrid PBL depths are larger
- Hybrid has ~30% low speed bias in lowest 300m, especially in southern SJV
- MM5-FDDA has ~15% high speed bias in lowest 200m
- Hybrid winds seem smoother

New MM5 Simulations

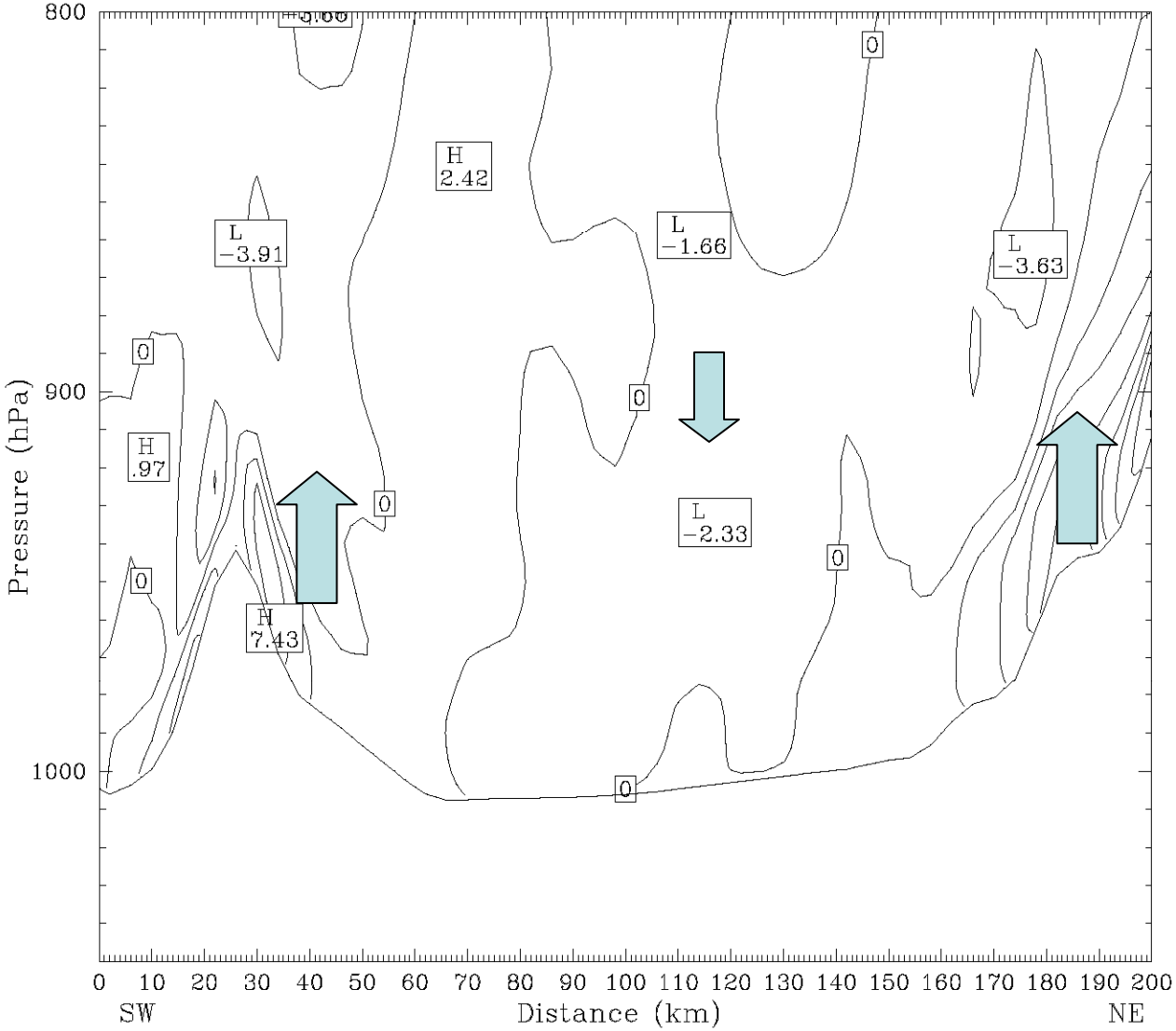
- Time-averaged output
- 1.3 km horizontal resolution

Time Averaged Winds – Cross Section



Dataset: mm54kmv3.6 avg RIP: rip.ccos.4kmmm5et Init: 1200 UTC Sat 29 Jul 00
Fcst: 30.00 Valid: 1800 UTC Sun 30 Jul 00 (1200 MDT Sun 30 Jul 00)
Vertical velocity XY= 75.0, 75.0 to 125.0, 75.0

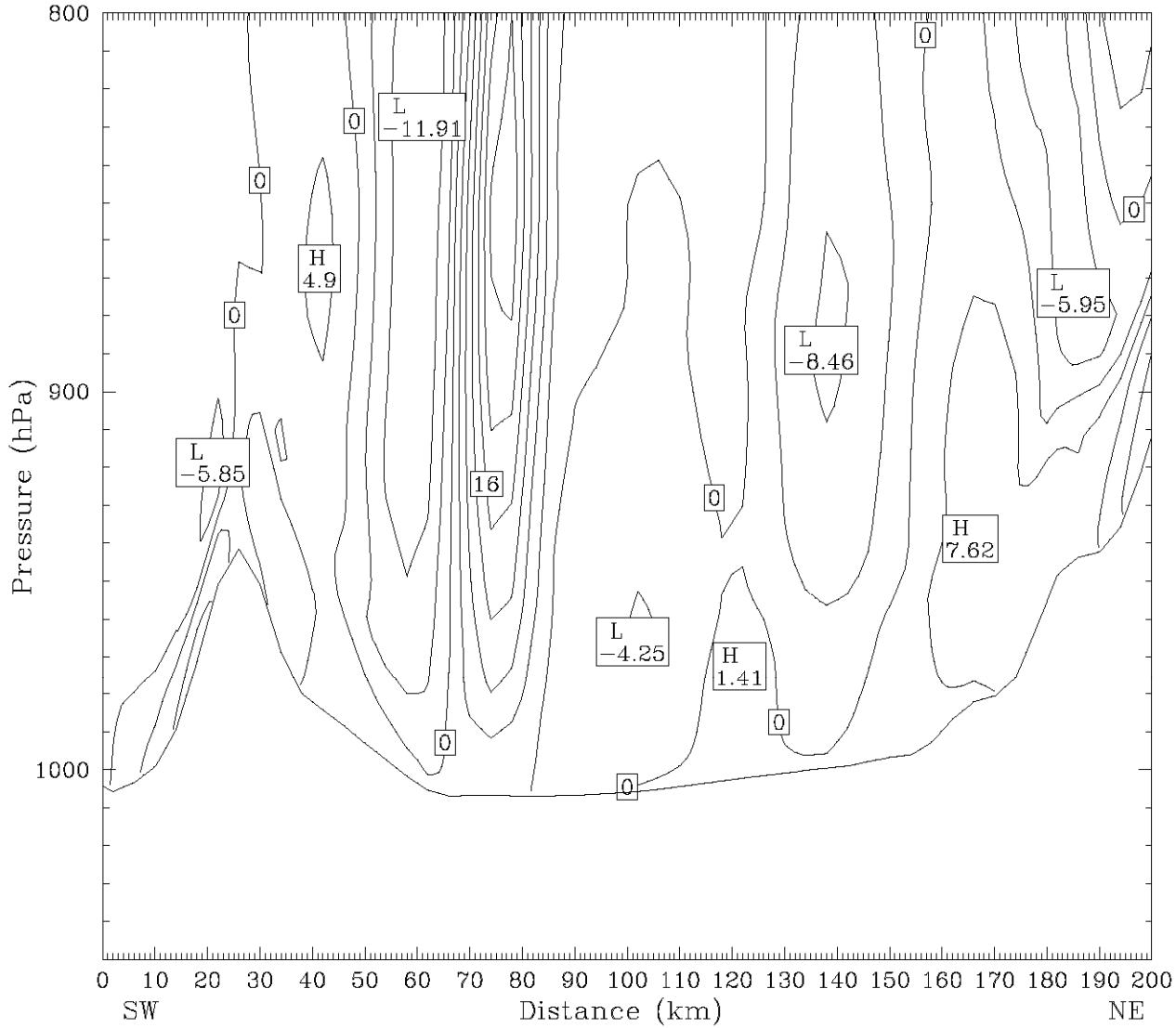
Hourly averaged MM5 Winds



CONTOURS: UNITS=cm s^{-1} LOW= −33.000 HIGH= 30.000 INTERVAL= 3.0000
Model info: V3.6.1 No Cumulus Eta PBL Simple ice 4 km, 50 levels, 1 sec

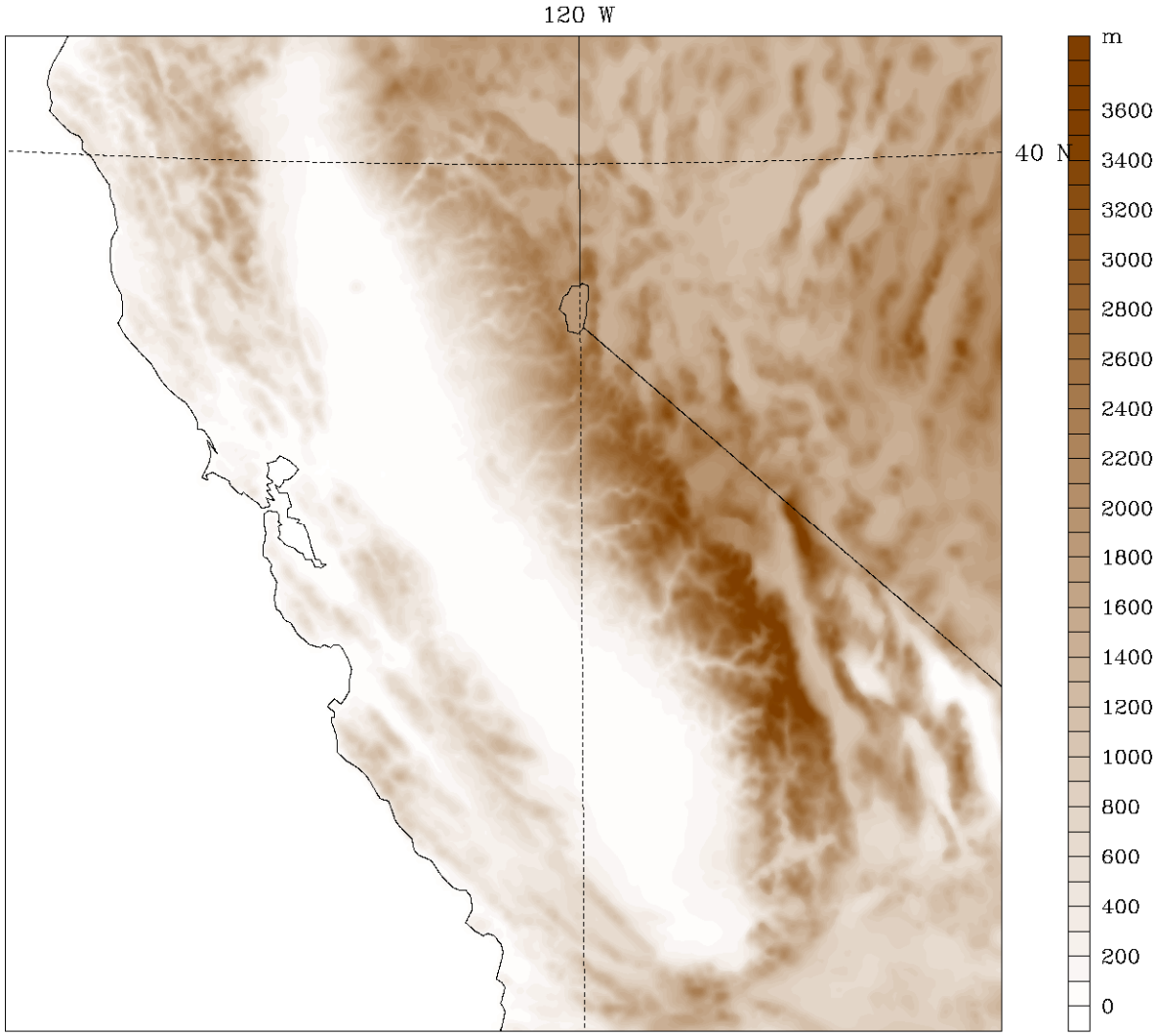
Dataset: mm54km1minraddt RIP: rip.ccos.4kmmm5e Init: 1200 UTC Sat 29 Jul 00
Fcst: 30.00 Valid: 1800 UTC Sun 30 Jul 00 (1200 MDT Sun 30 Jul 00)
Vertical velocity XY= 75.0, 75.0 to 125.0, 75.0

Instantaneous MM5 Winds



CONTOURS: UNITS=cm s^{-1} LOW= −52.000 HIGH= 32.000 INTERVAL= 4.0000

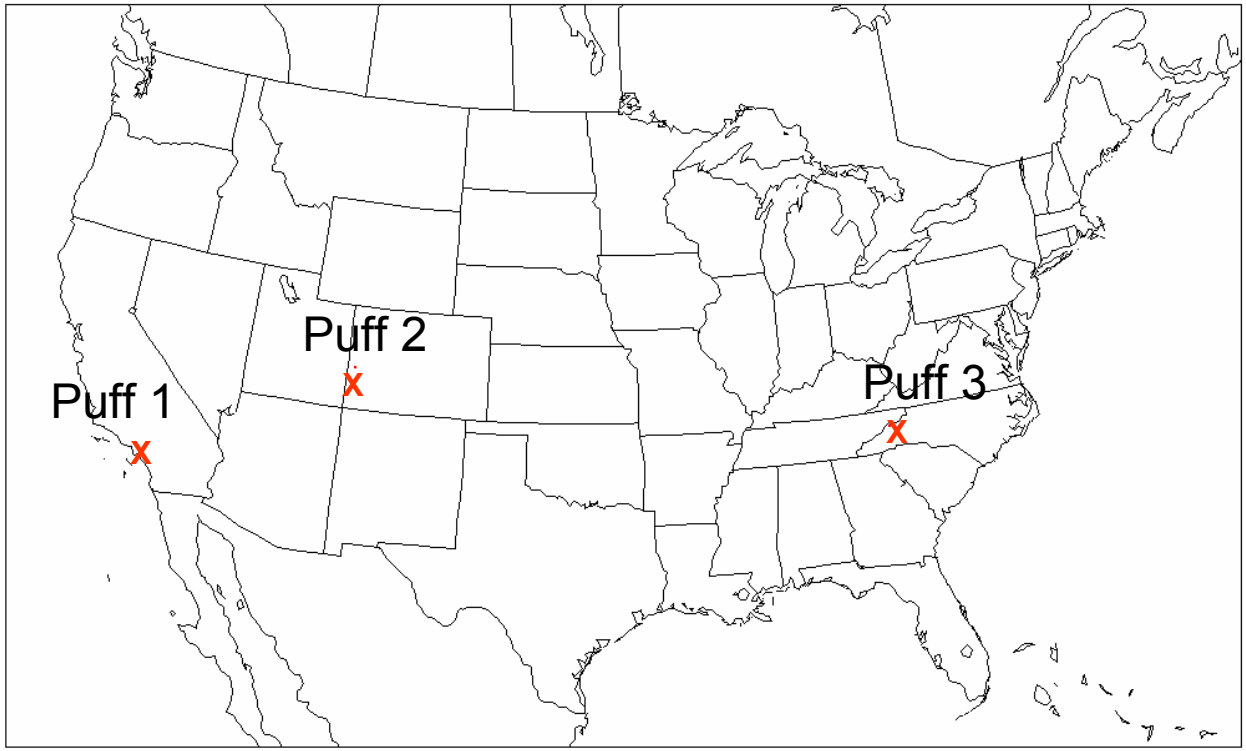
MM5 1.3 km domain (520x520)



Mass Conservation

- Two common methods
  - Concentration adjustment based on density
  - Diagnose artificial vertical velocity to balance continuity equation
- Two tests
  - Initial uniform concentration field remains uniform
  - Mass of puff remains constant

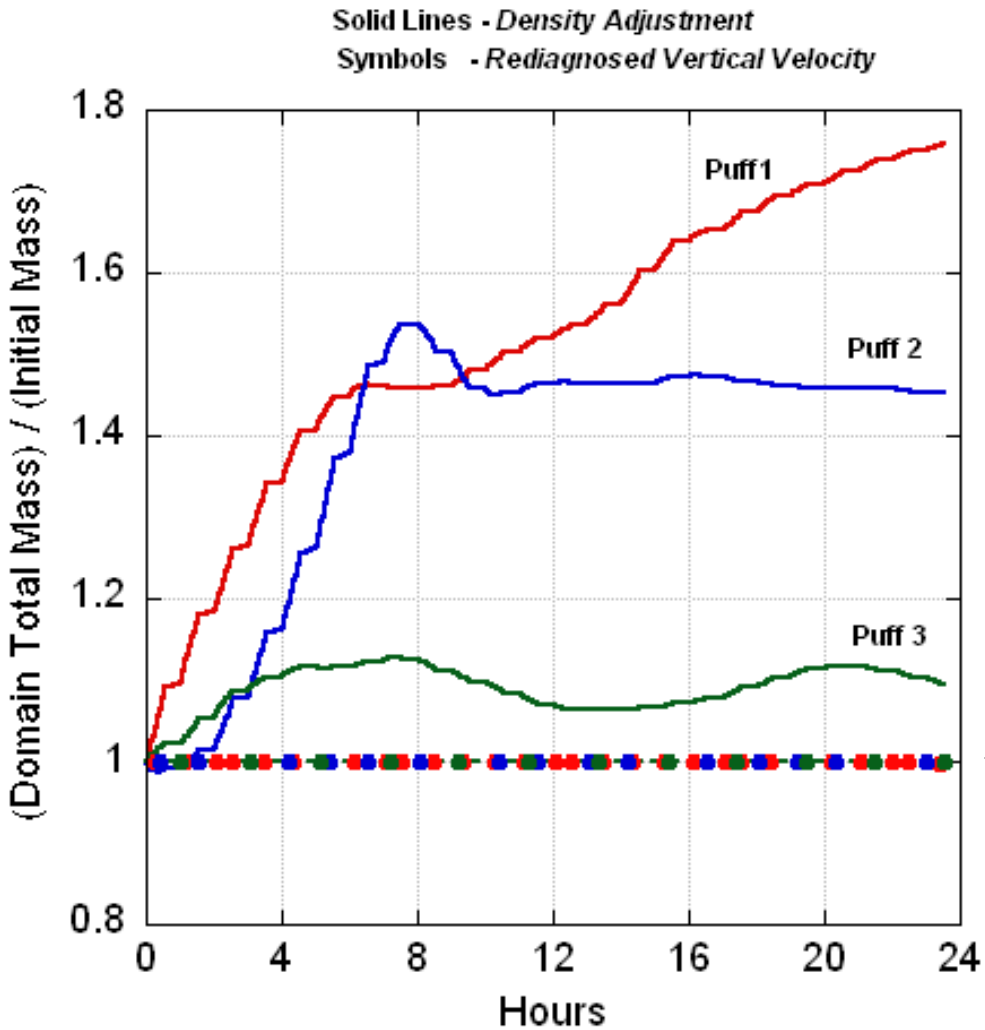
Eta-CMAQ Model



Tracked total domain mass of three initial puffs

Rohit Mathur, Ken Schere
(NOAA/EPA)

Variation in Domain Total Mass Relative to Initial Mass



Byun density Adjustment scheme

$$(CJ) = \frac{(CJ)_{adv} / (\rho J)_{adv}}{(\rho J)_{met}}$$

Yamartino scheme

$$\frac{\partial(\rho V)}{\partial t} = -\nabla \cdot (\rho V)$$

Rohit Mathur, Ken Schere
(NOAA/EPA)

- With density adjustment scheme turned on, an initially uniform concentration field will remain uniform, but mass of puff is not conserved.

- With density adjustment turned off, mass of puff is conserved, but an initially uniform field will develop local maxima and minima

- With re-diagnosed vertical velocity field (Yamartino) uniform concentration field and mass of puff tests are satisfied, but predicted ozone field is inaccurate because of unrealistic vertical velocities!

- Mass conservation errors are larger in regions of complex terrain

Mass Conservation Solution

- For MM5, use of time-averaged wind fields may help
- Use a meteorological model that conserves mass
- Use a chemical model that uses the identical advection scheme and grid structure as the met model

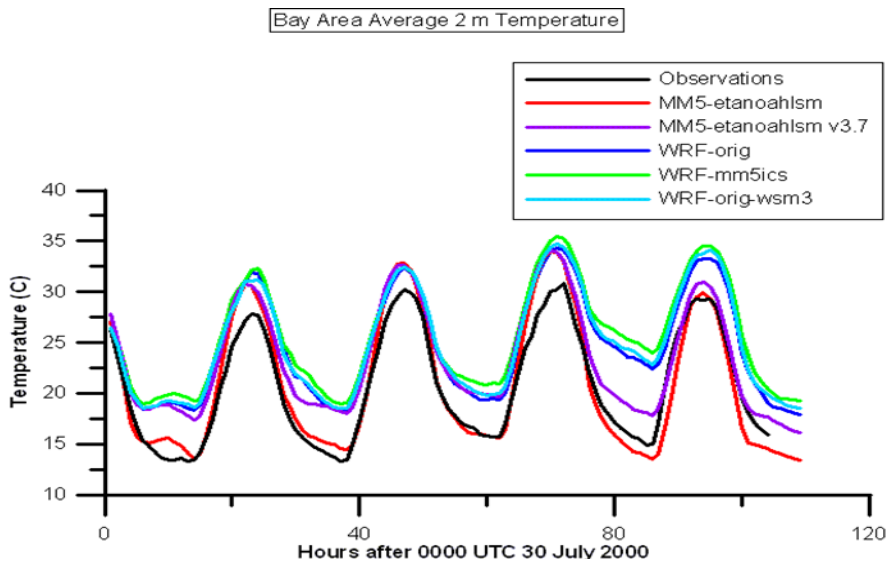
WRF-Chem!

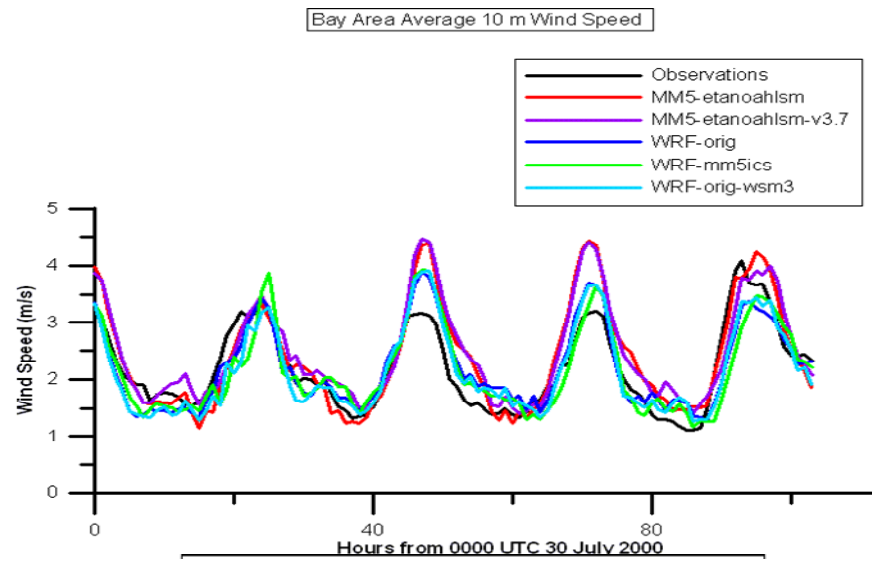
WRF Simulation

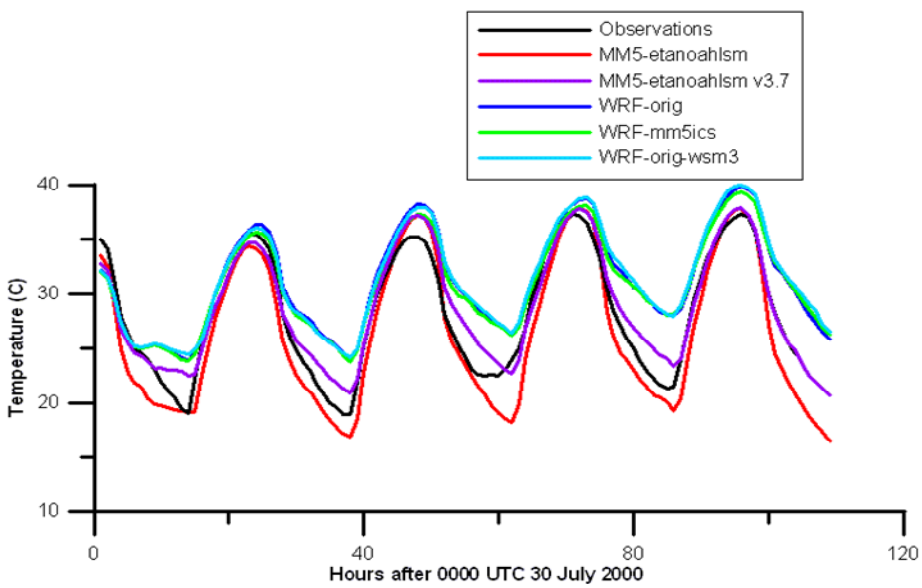
- the MYJ PBL and surface layer schemes
- the NOAH land surface model (LSM)
- the Dudhia short-wave, RRTM long-wave radiation schemes
- microphysics parameterization
  - WRF Lin et al.
  - MM5: Reisner
- convective scheme (only on the 36 km and 12 km grids)
  - WRF: Kain-Fritch
  - MM5: Grell

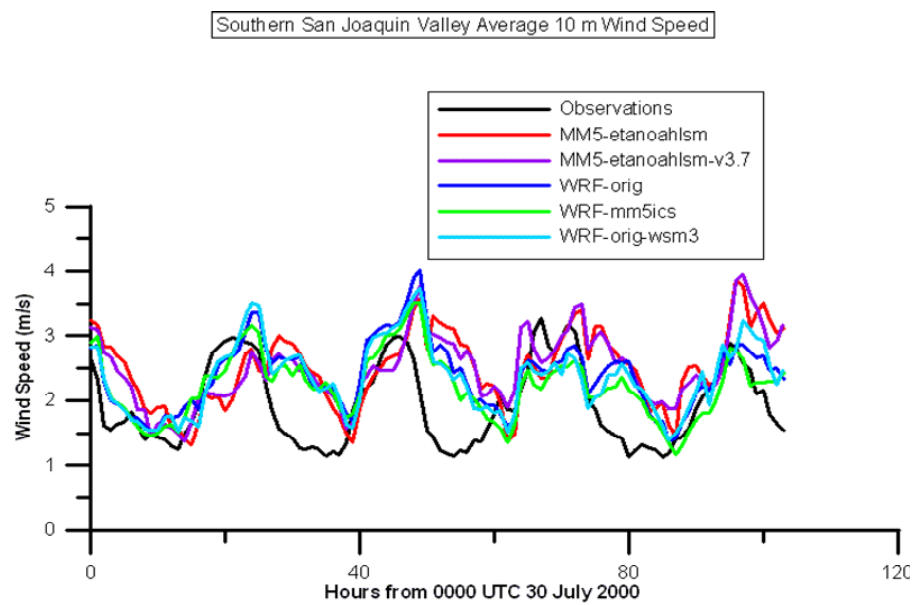
Temperature

Wind Speed

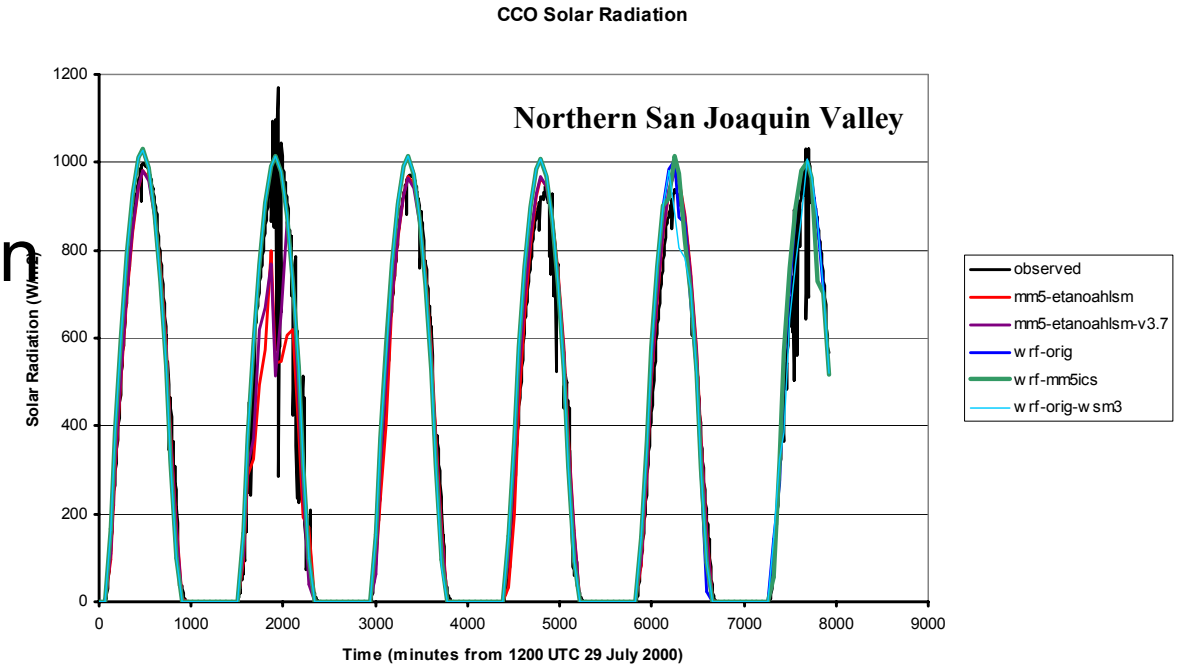


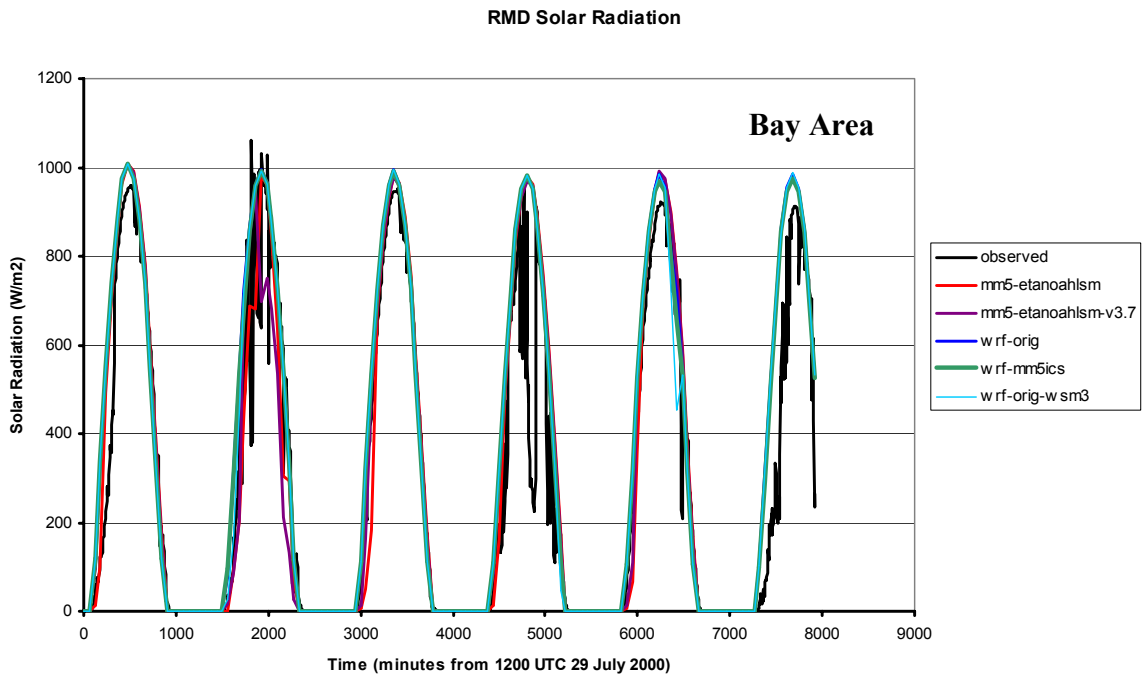






Solar radiation





Next Steps

- CCOS needs protocol on selecting observations to drive models
- Complete new FDDA scheme in MM5 interpolating obs to model levels at profiler sites
- For surface wind obs at non-profiler sites, how high do we nudge the model? Sensitivity tests.
- Analyze 1.3 km MM5 run
- Compare MM5 with met fields used within CAMx
- Run WRF-Chem on-line/off-line to assess possible mass conservation errors