PROGRESS REPORT ON THE SEASONAL MODELING PROJECT: METEOROLOGY

Jian-Wen Bao, Sara A. Michelson, Ola Persson, Laura Bianco, Irina Djalalova, David White, James Wilczak

NOAA Earth System Research Laboratory
(Formerly NOAA Environmental Technology Laboratory)

Nancy Brown Robert Harley Ling Jin Shaheen Tonse

Lawrence Berkeley National Laboratory and University Of California at Berkeley

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Project Goals

- Demonstrate that meteorological model works equally well at replicating seasonal climatology as it does for IOP episode.

- Use meteorological observations and model simulations to understand processes influencing ozone concentrations in central California.

Process Studies

- Identify and quantify meteorological phenomena/process in observational summer climatologies (e.g., inflow strength, flow splitting, nocturnal jet…)
- Demonstrate that model replicates climatology of these processes
- Stratify the data into periods w/wo each phenomenon for both observations and model, check ozone response.
  - Which phenomena are important?
  - Does model get correct ozone response for each of them?

NOAA Tasks

1. Provide QC'd wind and temperature data
2. Provide boundary layer depths
3. Provide optimized meteorological simulations.
4. Assess skill of model simulations
5. Analyze observed and modeled summer meteorological "climatology", and roles of specific atmospheric phenomena on ozone.

Summer Season

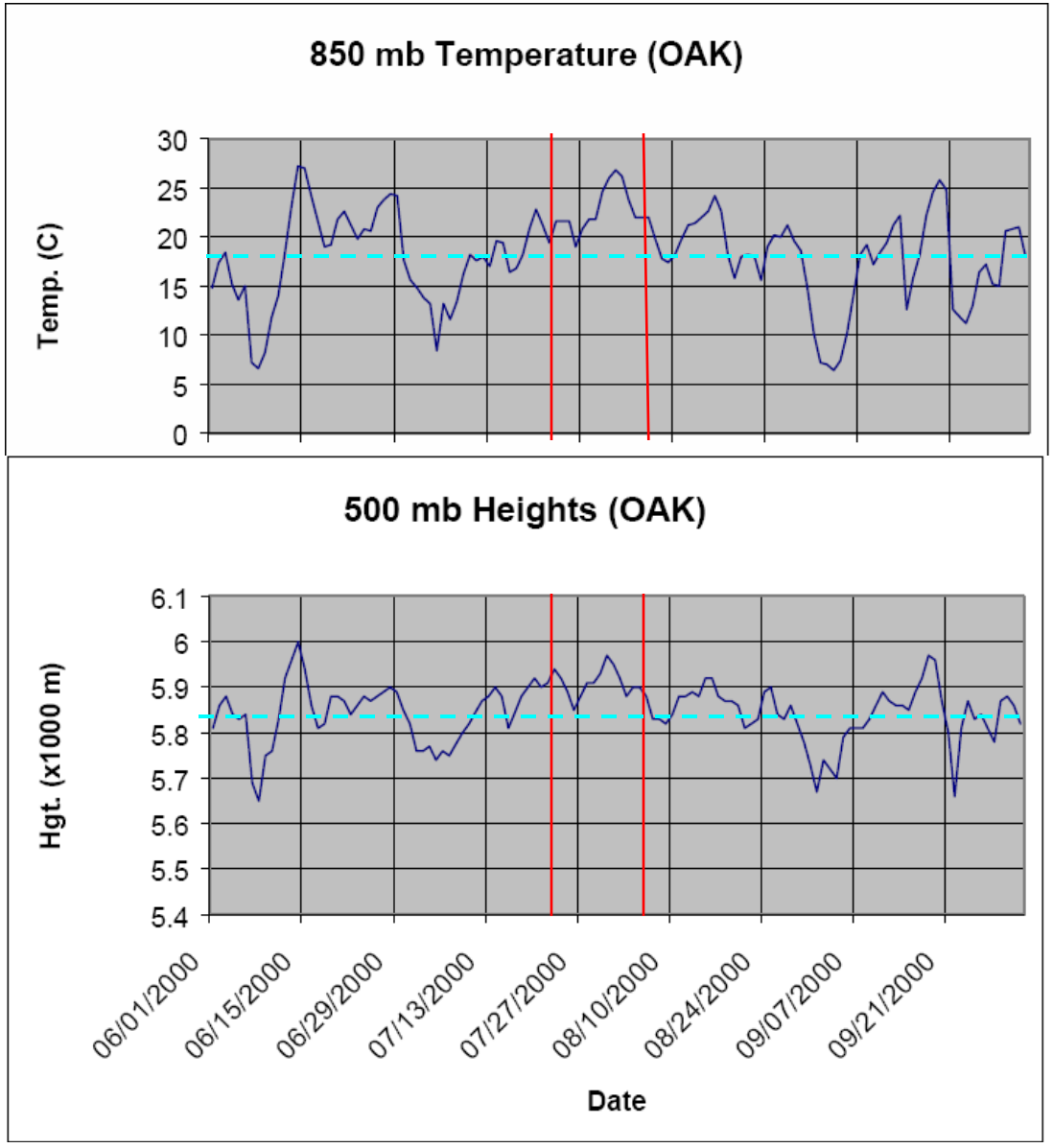
1 June – 2 October 2000 (124 days)

Model Simulations

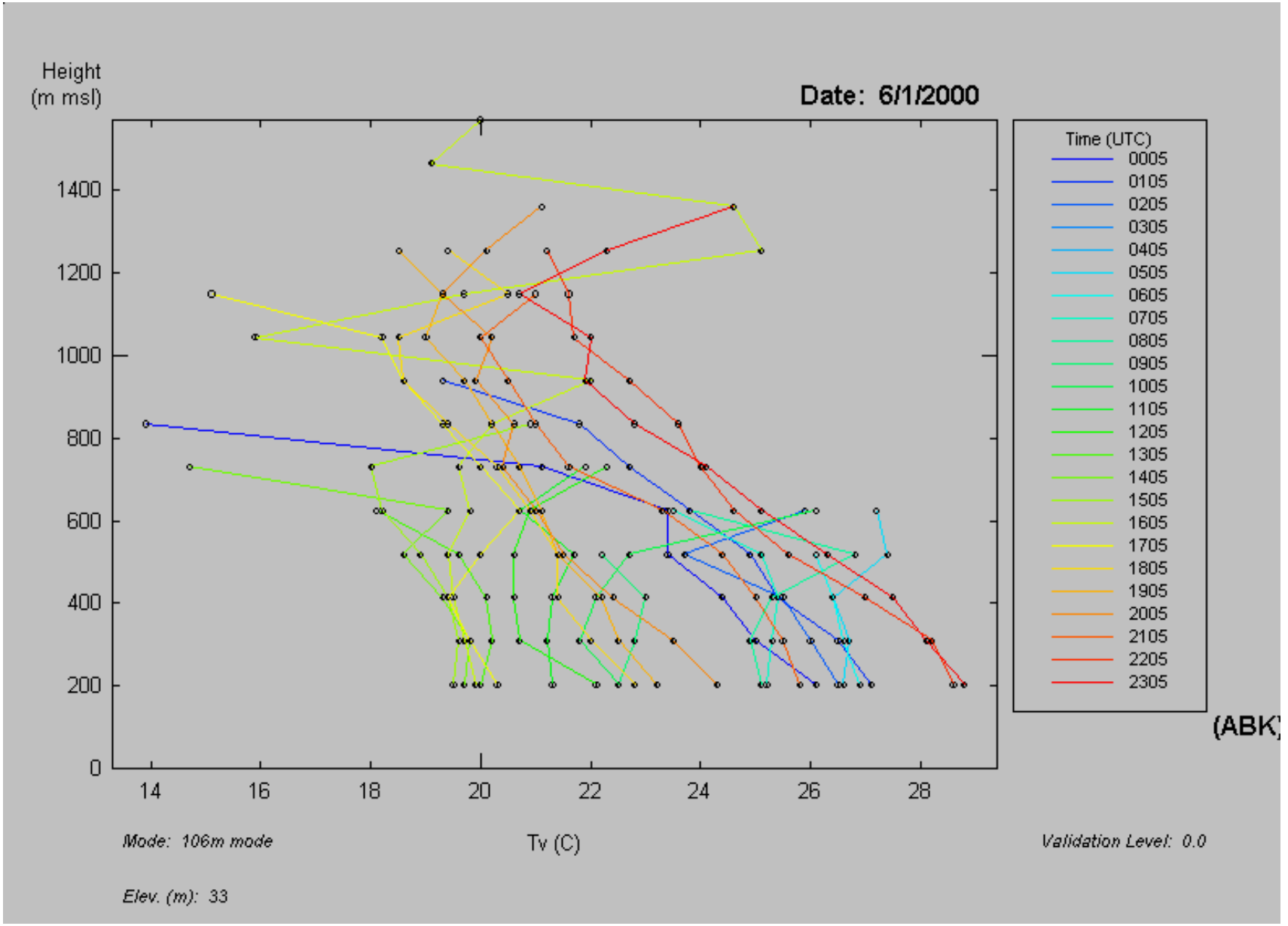
(No FDDA)

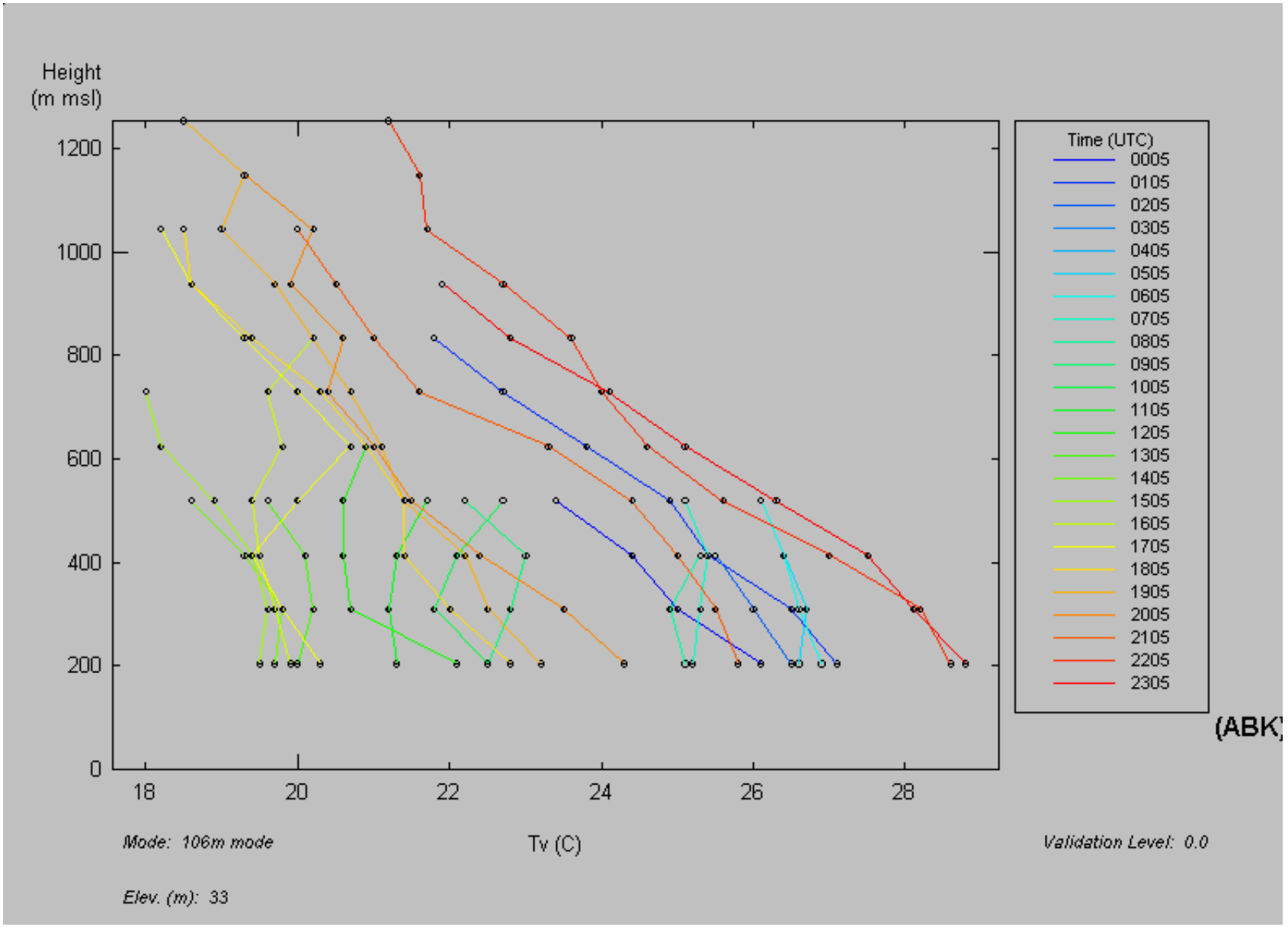
1. 24 July - 29 July
2. 29 July – 03 August
3. 03 August – 08 August

SYNOPTC OVERVIEW

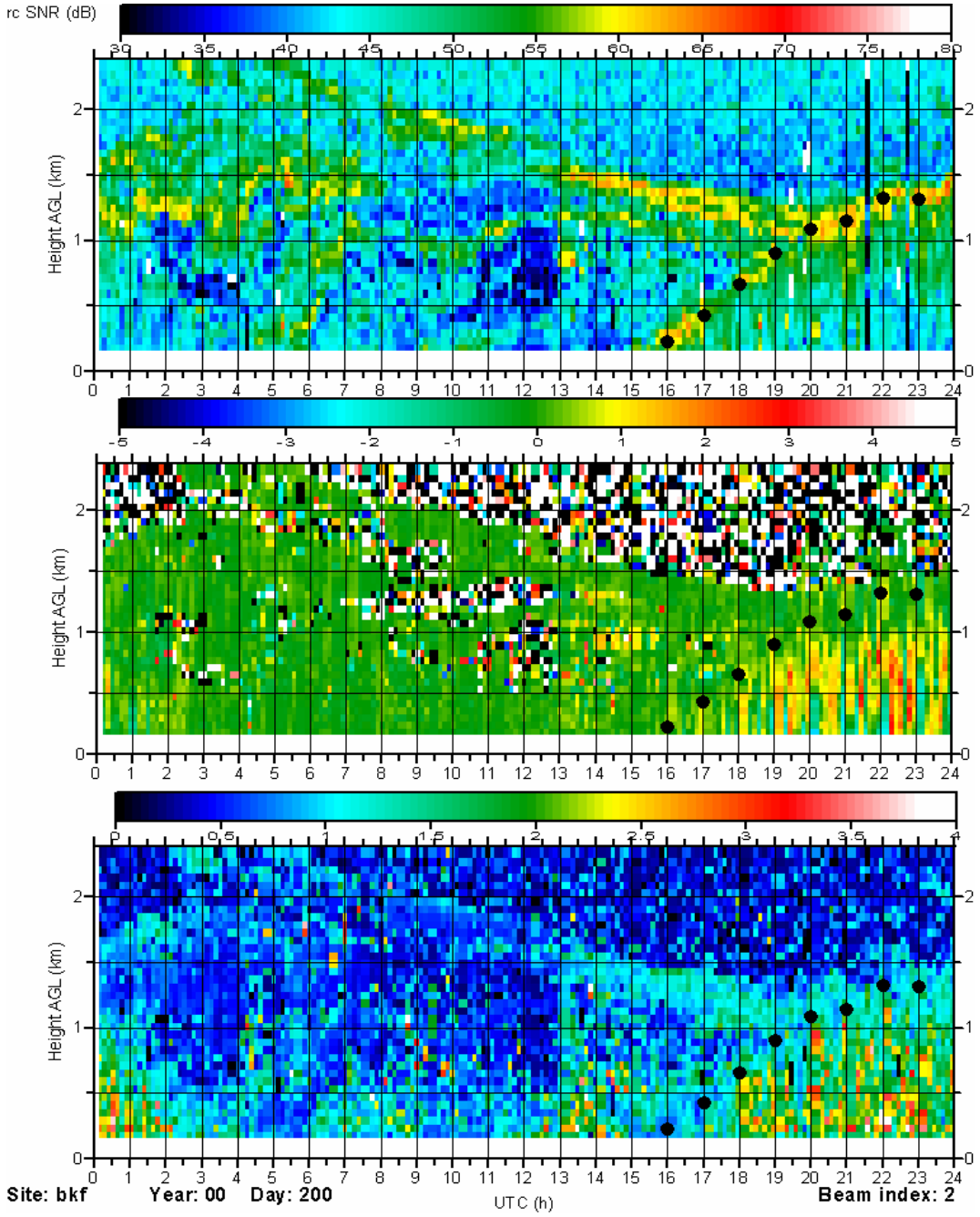


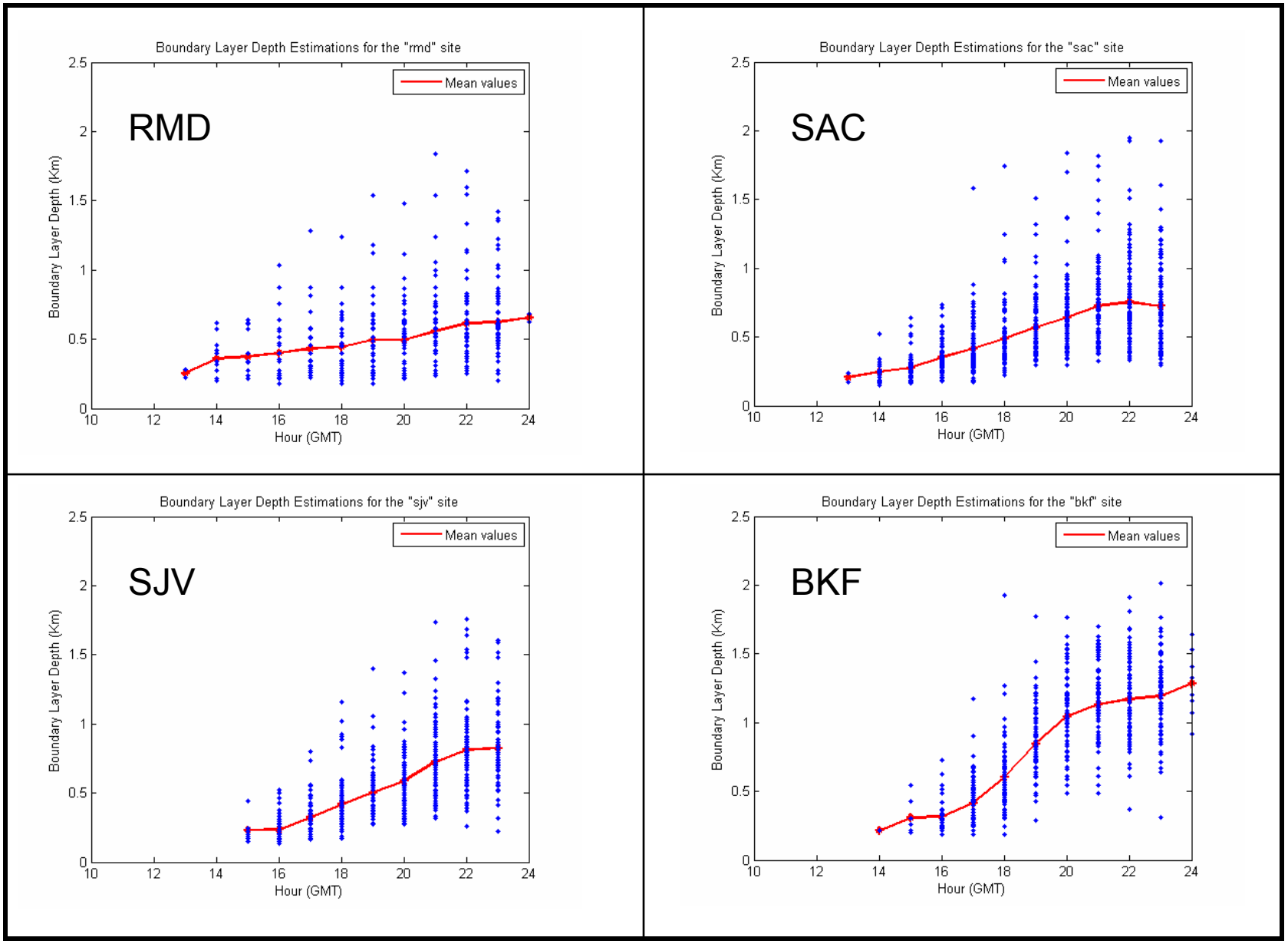
From the CCOS 2000 Interim report, entitled "Characterization Of The CCOS 2000 Measurement Period" by Don Lehrman David Fairley, Bill Knuth


Height
(m msl)
Date: 6/1/2000
Time (UTC)
0005
0105
0205
0305
0405
0505
0605
0705
0805
0905
1005
1105
1205
1305
1405
1505
1605
1705
1805
1905
2005
2105
2205
2305
1400
1200
1000
800
600
400
200
0
14
16
18
20
22
24
26
28
Tv (C)
Mode: 106m mode
Elev. (m): 33
Validation Level: 0.0
(ABK)

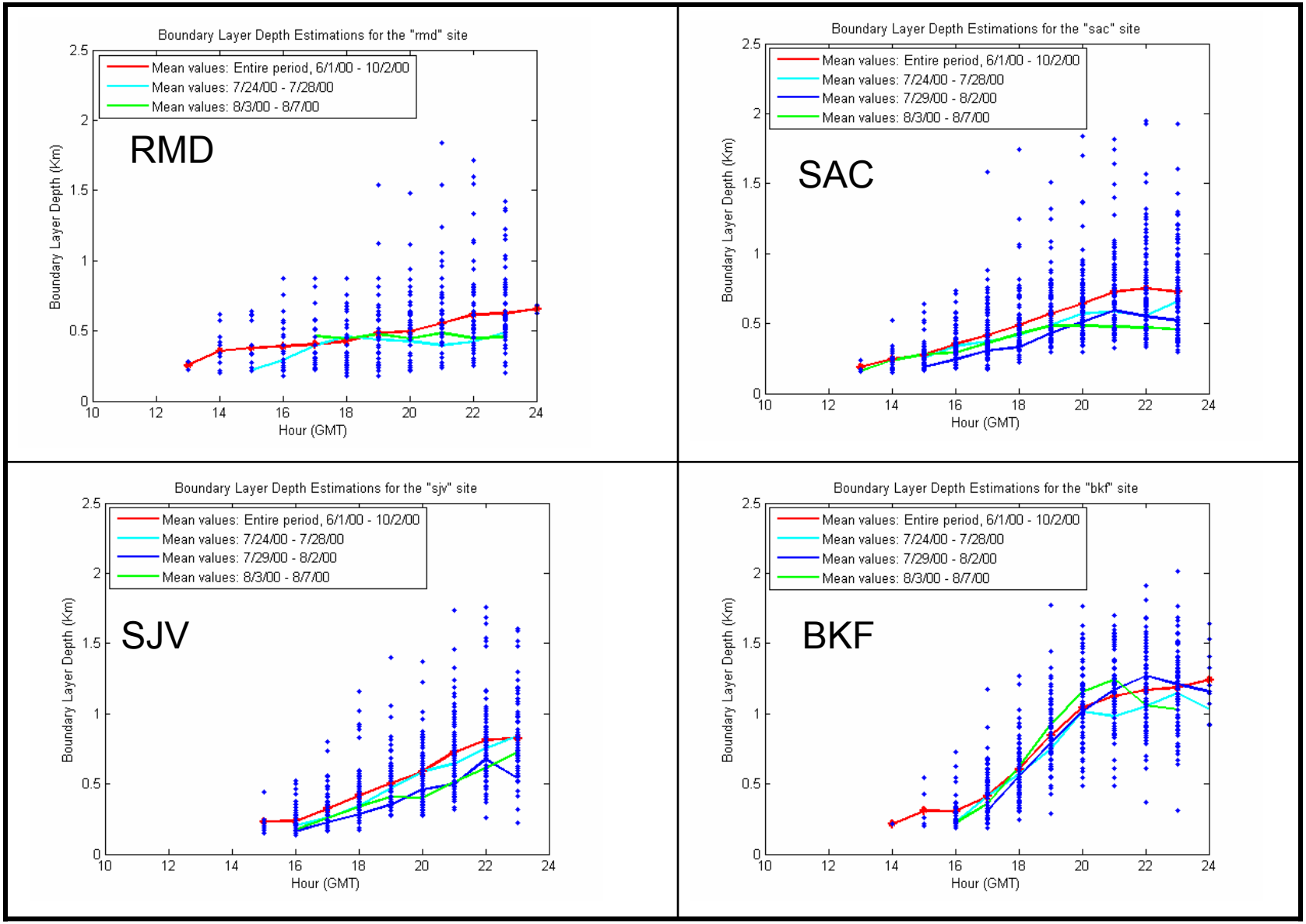


6.7 million data points visually inspected


rc SNR (dB)
30 35 40 45 50 55 60 65 70 75 80
Height AGL (km)
0 1 2
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
-5 -4 -3 -2 -1 0 1 2 3 4 5
Height AGL (km)
0 1 2
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
0 0.5 1 1.5 2 2.5 3 3.5 4
Height AGL (km)
0 1 2
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Site: bkf
Year: 00
Day: 200
UTC (h)
Beam index: 2



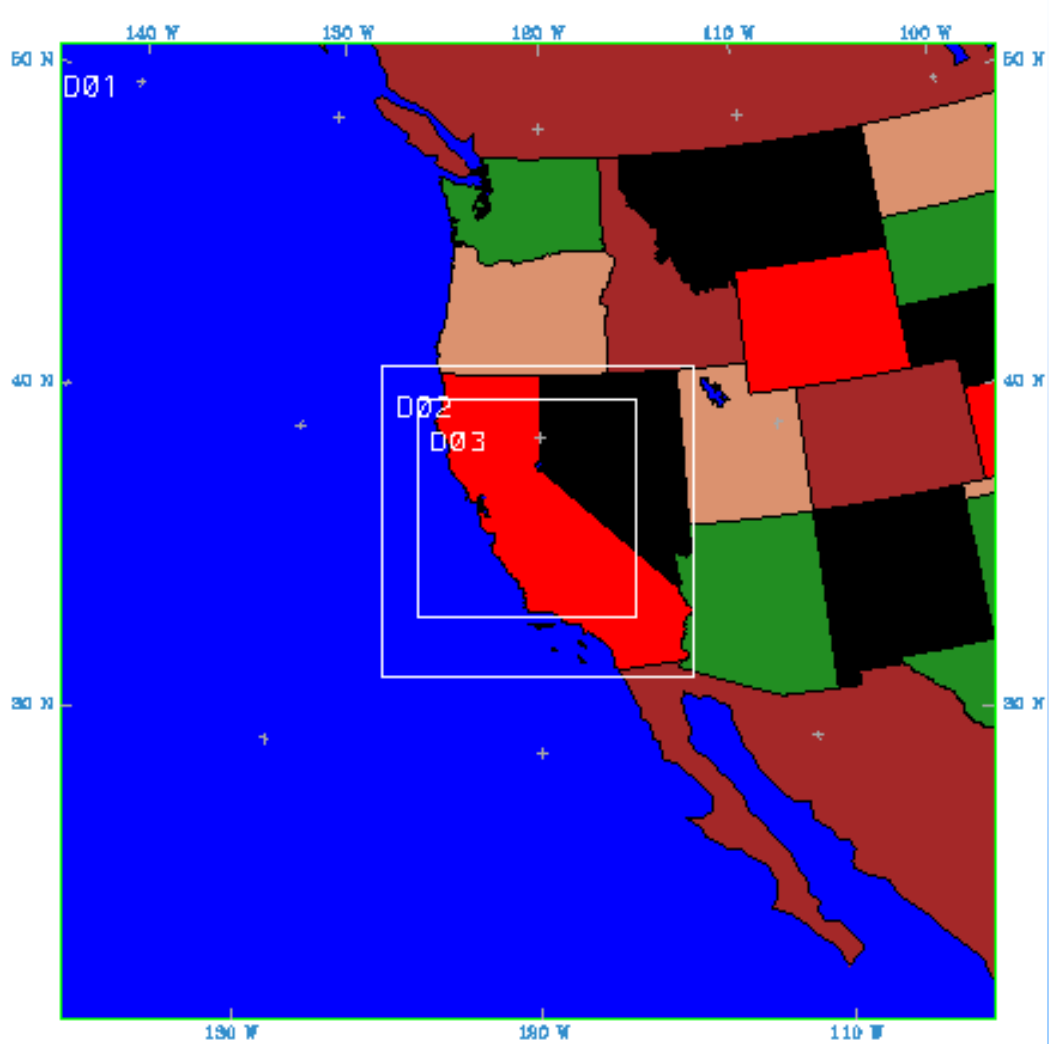
PBL depth climatology



PBL depth climatology

OUTLINE

- Quantitative evaluation of the model simulations
- Model aided low-level wind analysis
- Improvement to FDDA
- Conclusions



36km grid 95x91

12km grid 91x91

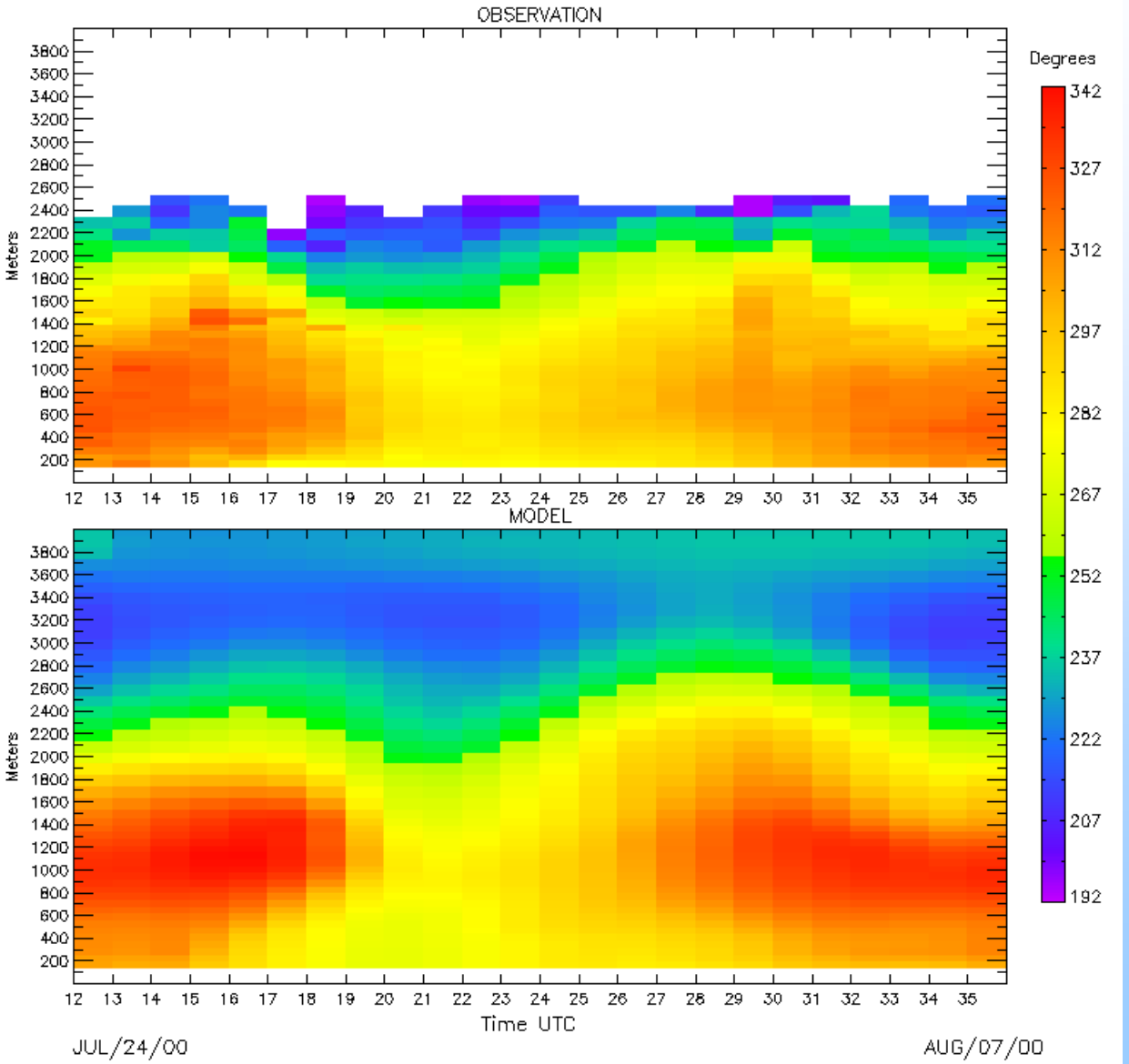
4km grid 190x190

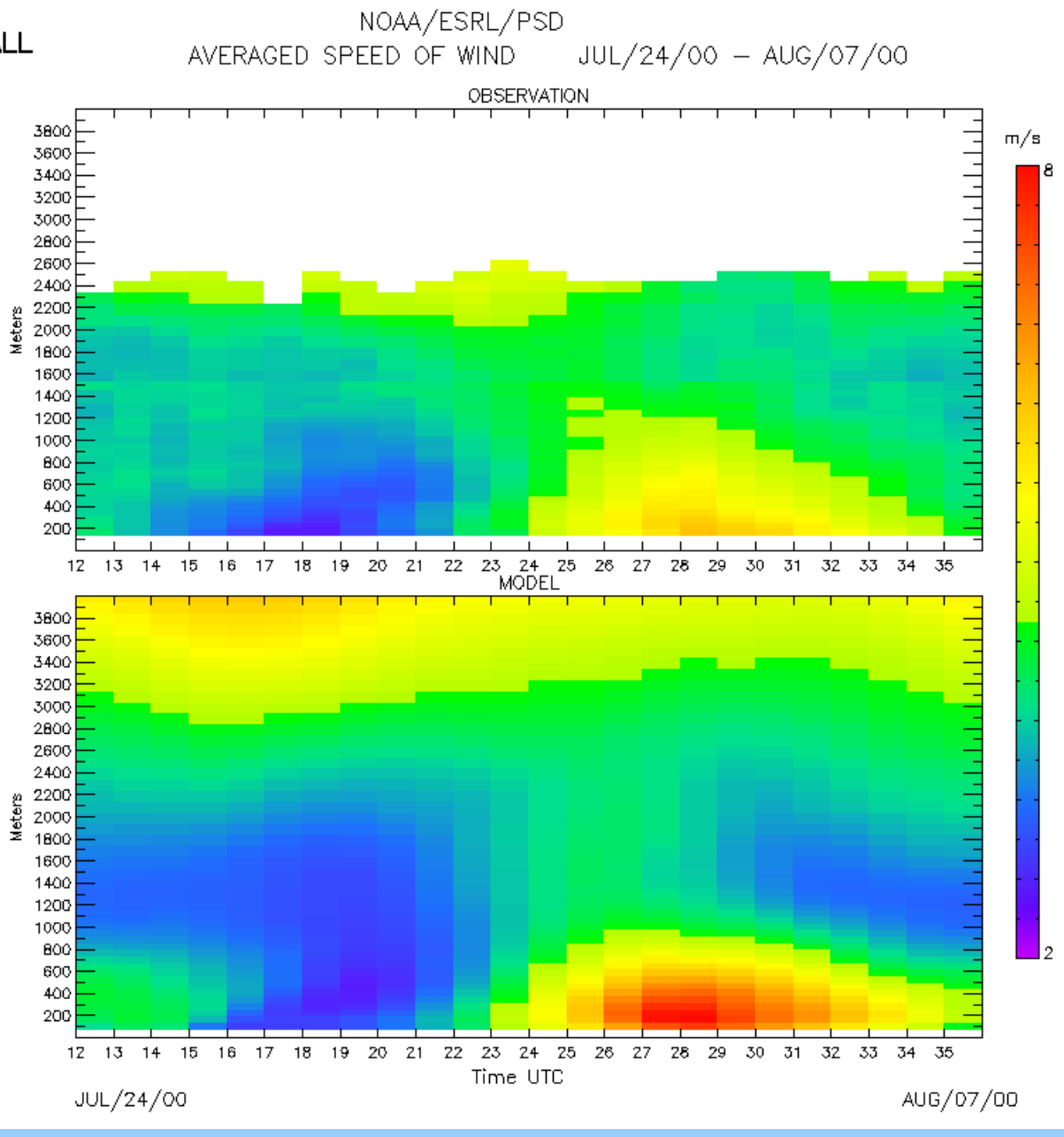
All have 50 layers, with 22 in lowest 1km

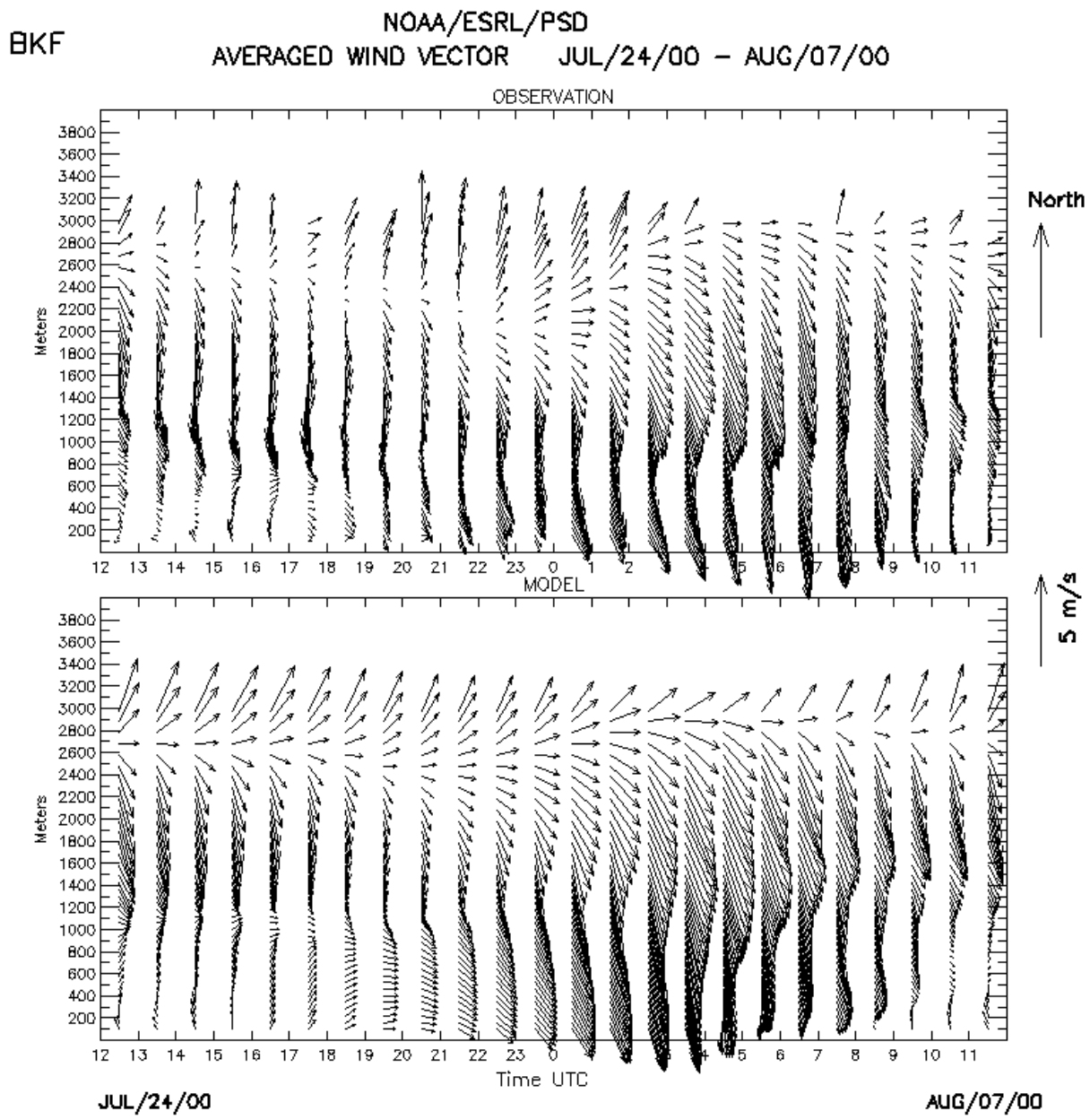
Three sequential 120-h simulations using MM5 V3.7 for the period of 1200 UTC July 24 – 1200 UTC August 8, 2000

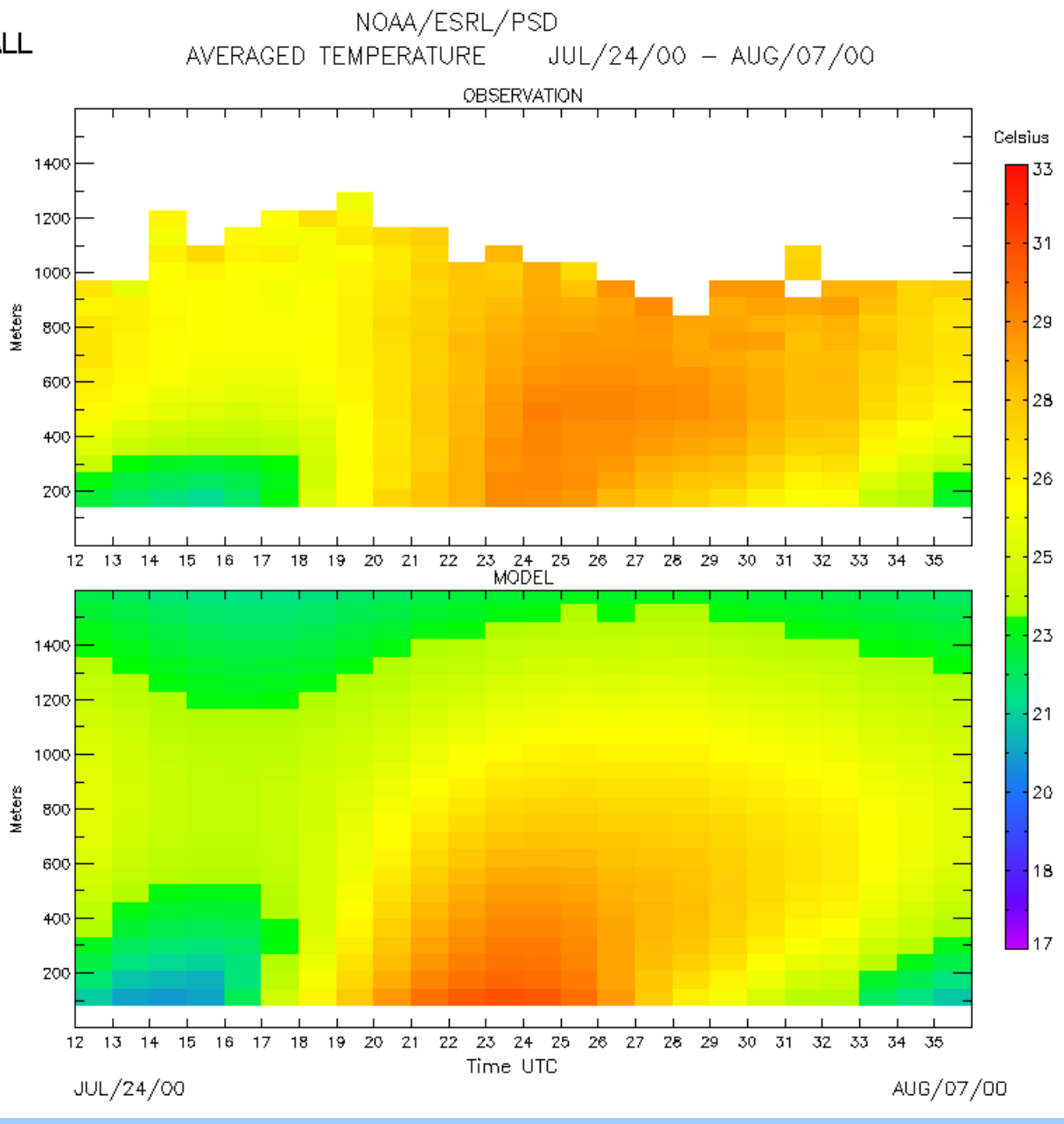
Physics in MM5-v3.7

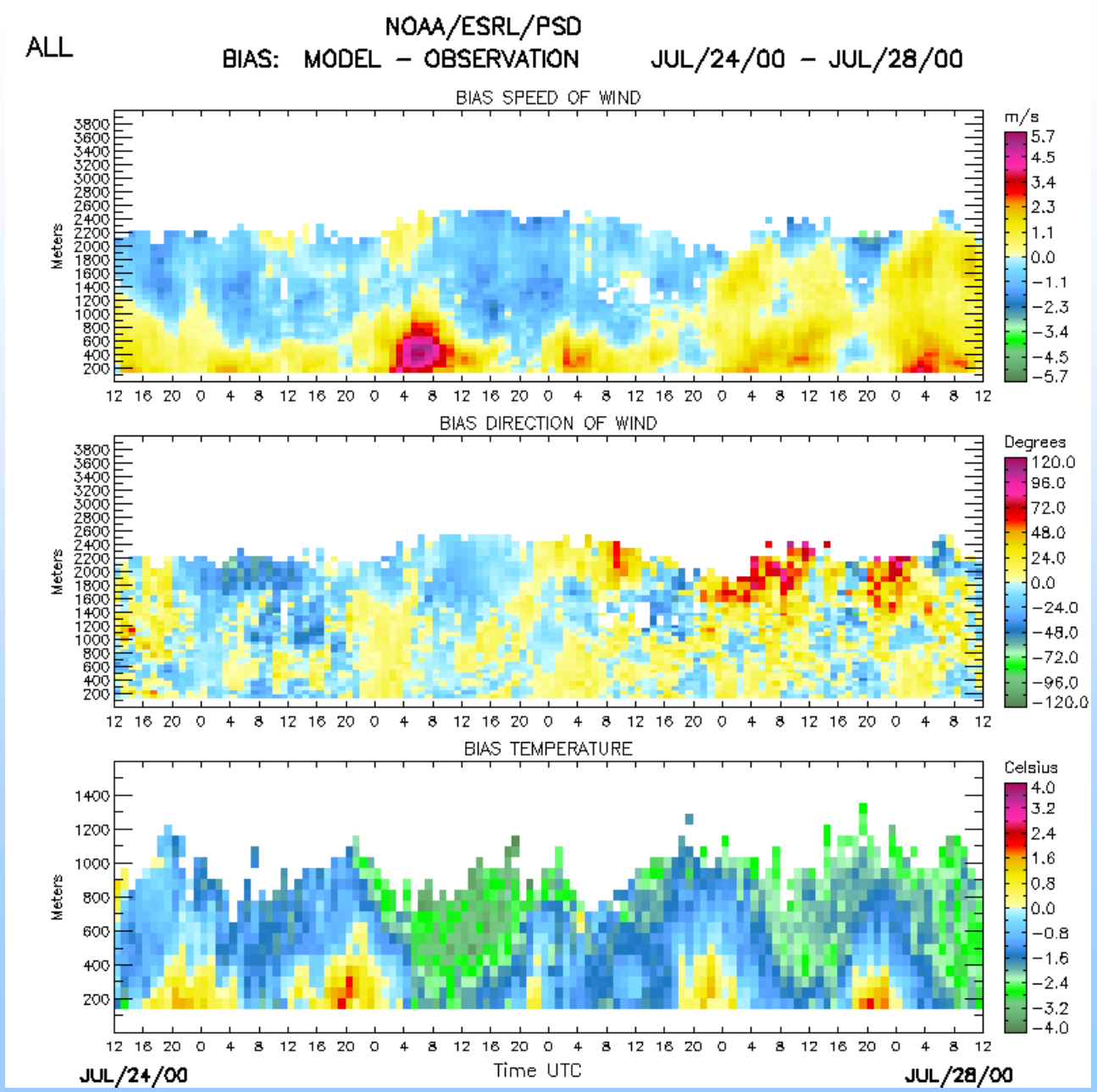
- the MYJ ABL and surface layer schemes
- the NOAH land surface model (LSM)
- the Dudhia short-wave, RRTM long-wave schemes
- the Reisner microphysics parameterization
- the Grell convective scheme (only on the 36 and 12 km grids)

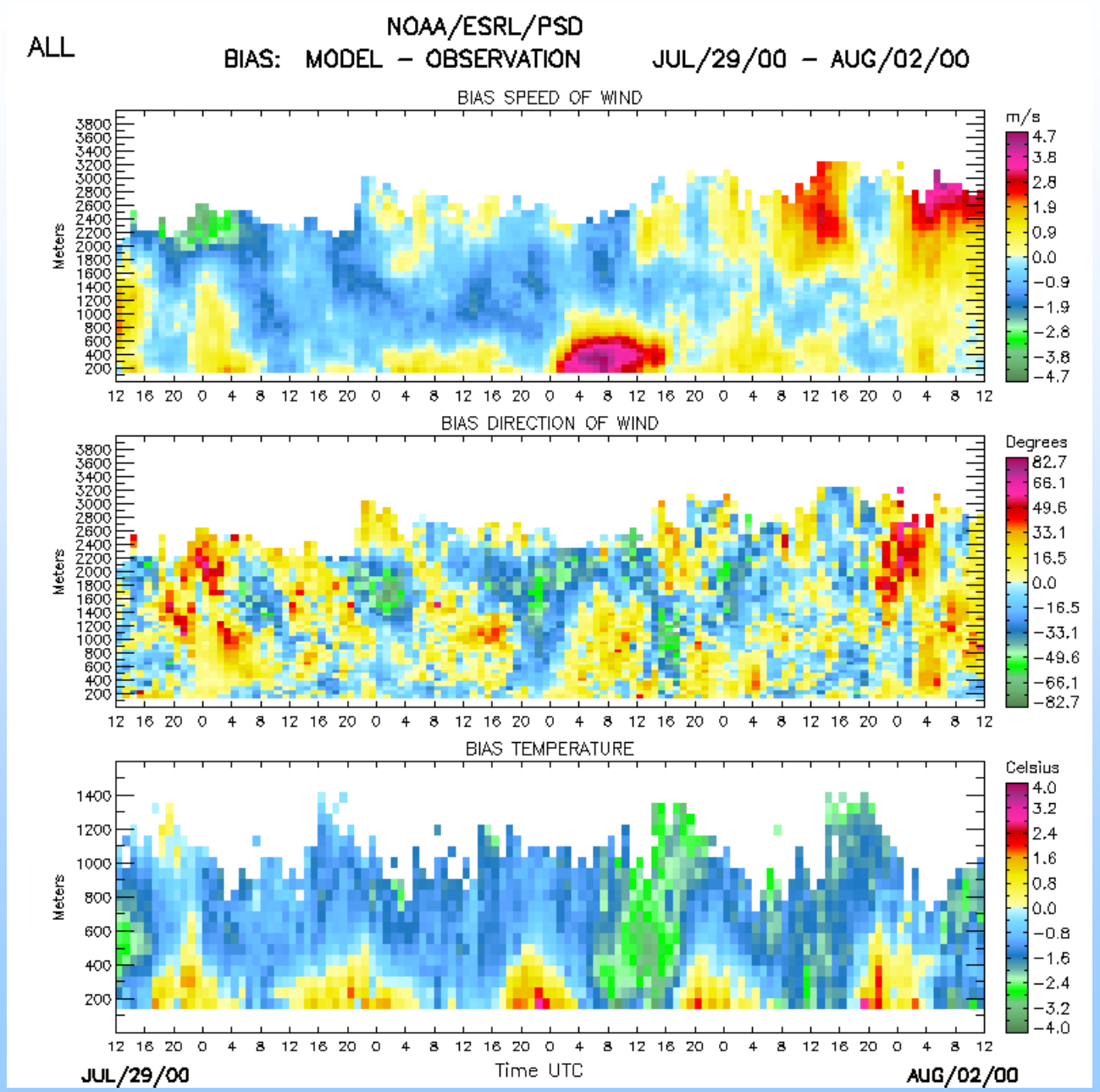

ALL
NOAA/ESRL/PSD
AVERAGED DIRECTION OF WIND JUL/24/00 – AUG/07/00
OBSERVATION
MODEL
Meters
Degrees
342
327
312
297
282
267
252
237
222
207
192
Time UTC
JUL/24/00
AUG/07/00

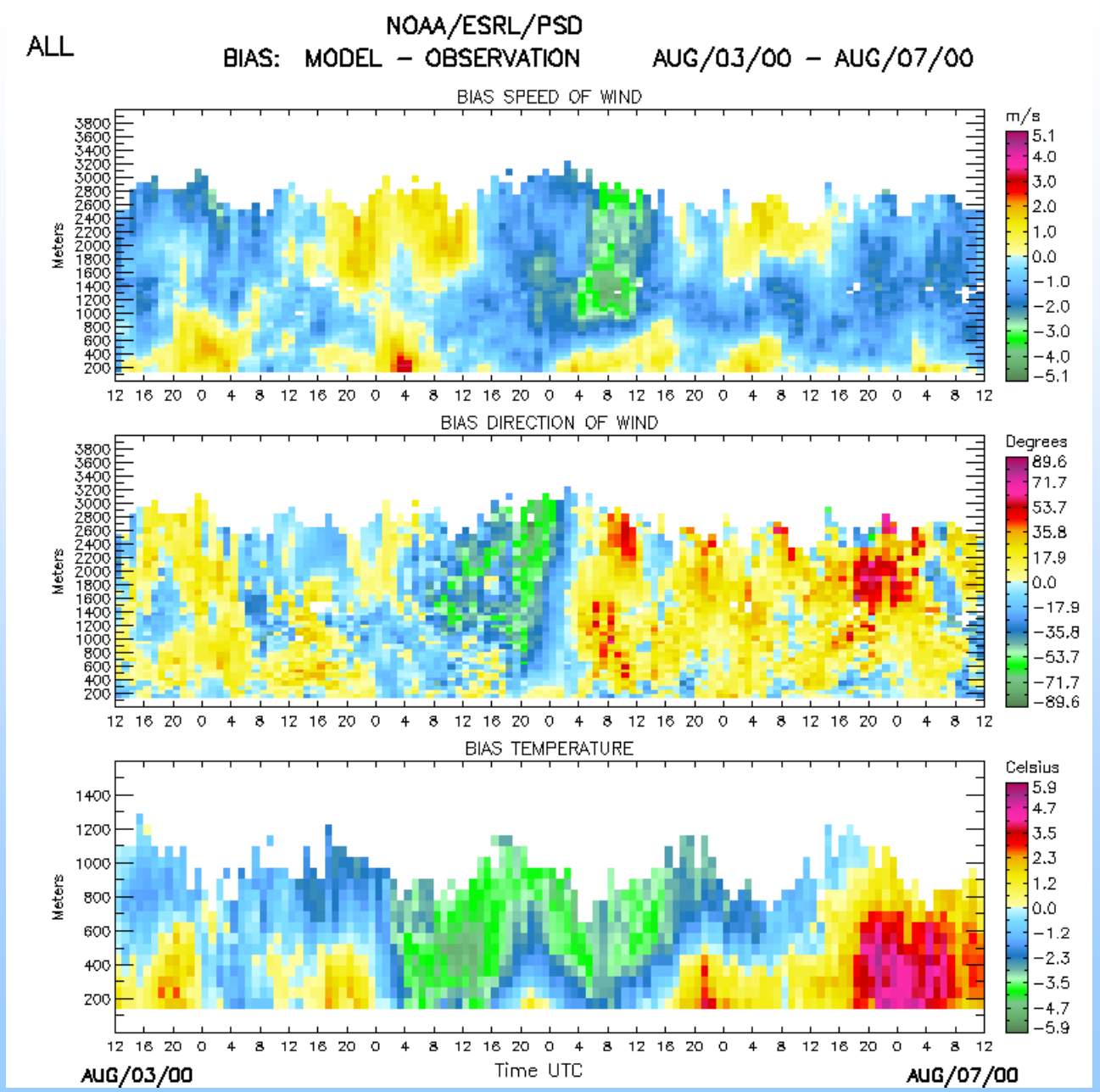

ALL
NOAA/ESRL/PSD
AVERAGED SPEED OF WIND JUL/24/00 – AUG/07/00
OBSERVATION
MODEL
Meters
m/s
8
2
Time UTC
JUL/24/00
AUG/07/00


BKF
NOAA/ESRL/PSD
AVERAGED WIND VECTOR JUL/24/00 – AUG/07/00
OBSERVATION
MODEL
Meters
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
12 13 14 15 16 17 18 19 20 21 22 23 0 1 2 3 4 5 6 7 8 9 10 11
Time UTC
North
5 m/s
JUL/24/00
AUG/07/00


ALL
NOAA/ESRL/PSD
AVERAGED TEMPERATURE JUL/24/00 – AUG/07/00
OBSERVATION
MODEL
Meters
1400
1200
1000
800
600
400
200
12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Time UTC
JUL/24/00
AUG/07/00
Celsius
33
31
29
28
26
25
23
21
20
18
17

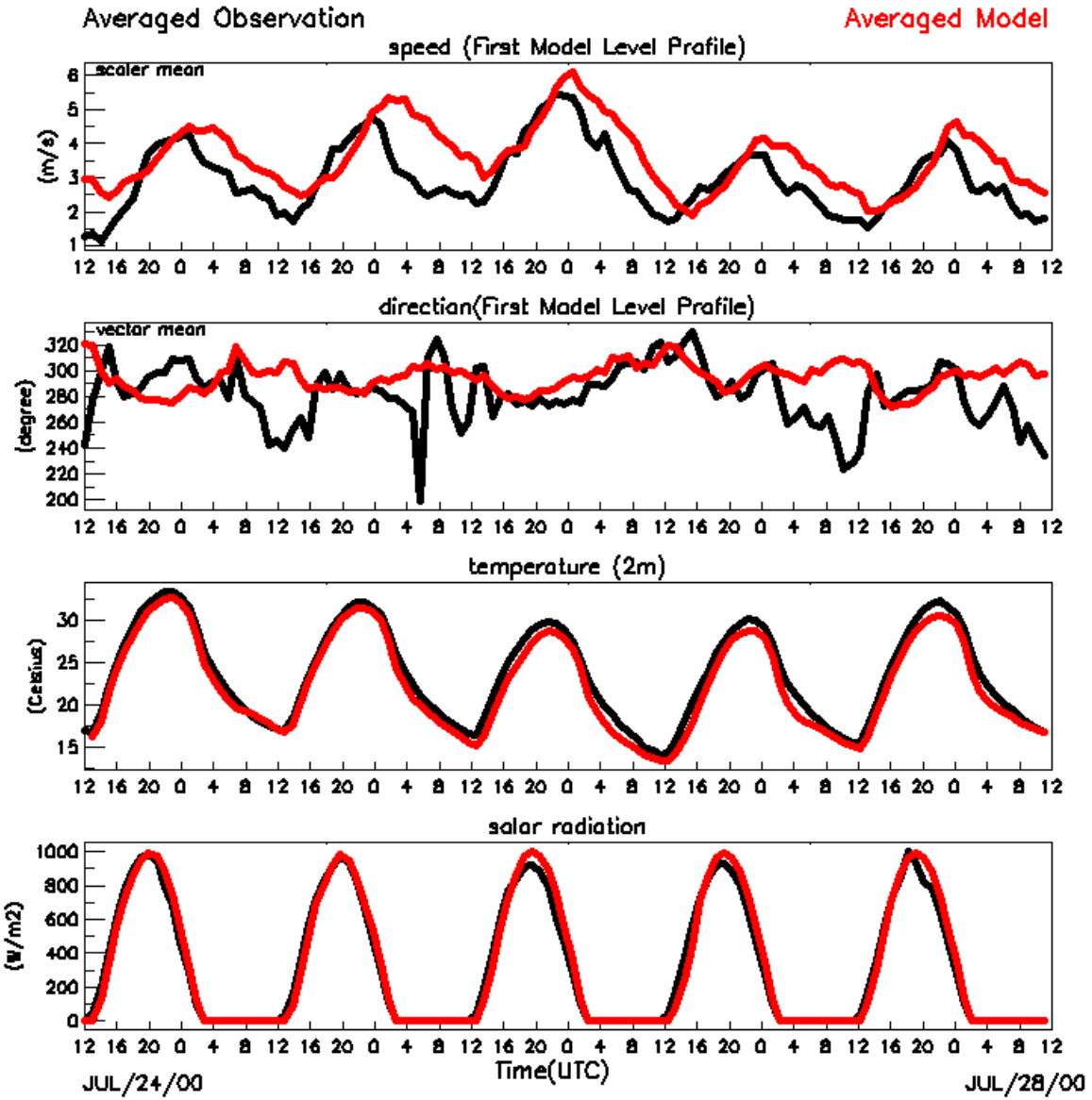

ALL
NOAA/ESRL/PSD
BIAS: MODEL – OBSERVATION
JUL/24/00 – JUL/28/00
BIAS SPEED OF WIND
m/s
5.7
4.5
3.4
2.3
1.1
0.0
−1.1
−2.3
−3.4
−4.5
−5.7
Meters
BIAS DIRECTION OF WIND
Degrees
120.0
96.0
72.0
48.0
24.0
0.0
−24.0
−48.0
−72.0
−96.0
−120.0
BIAS TEMPERATURE
Celsius
4.0
3.2
2.4
1.6
0.8
0.0
−0.8
−1.6
−2.4
−3.2
−4.0
Time UTC
JUL/24/00
JUL/28/00

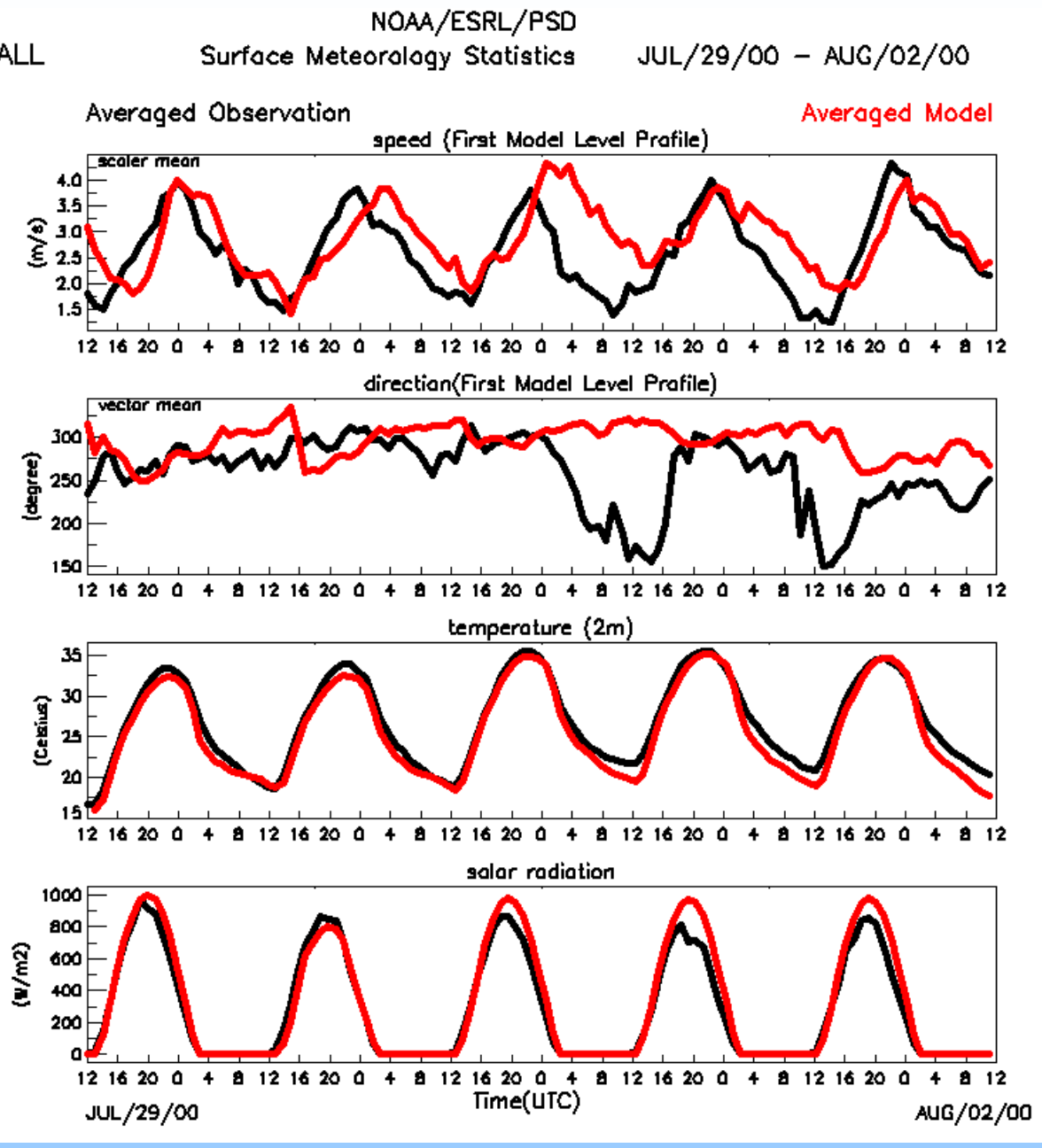

ALL
NOAA/ESRL/PSD
BIAS: MODEL – OBSERVATION
JUL/29/00 – AUG/02/00
BIAS SPEED OF WIND
m/s
4.7
3.8
2.8
1.9
0.9
0.0
−0.9
−1.9
−2.8
−3.8
−4.7
Meters
3800 3600 3400 3200 3000 2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600 400 200
12 16 20 0 4 8 12 16 20 0 4 8 12 16 20 0 4 8 12 16 20 0 4 8 12 16 20 0 4 8 12
BIAS DIRECTION OF WIND
Degrees
82.7
66.1
49.6
33.1
16.5
0.0
−16.5
−33.1
−49.6
−66.1
−82.7
Meters
3800 3600 3400 3200 3000 2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600 400 200
12 16 20 0 4 8 12 16 20 0 4 8 12 16 20 0 4 8 12 16 20 0 4 8 12 16 20 0 4 8 12
BIAS TEMPERATURE
Celsius
4.0
3.2
2.4
1.6
0.8
0.0
−0.8
−1.6
−2.4
−3.2
−4.0
Meters
1400 1200 1000 800 600 400 200
12 16 20 0 4 8 12 16 20 0 4 8 12 16 20 0 4 8 12 16 20 0 4 8 12 16 20 0 4 8 12
JUL/29/00
Time UTC
AUG/02/00

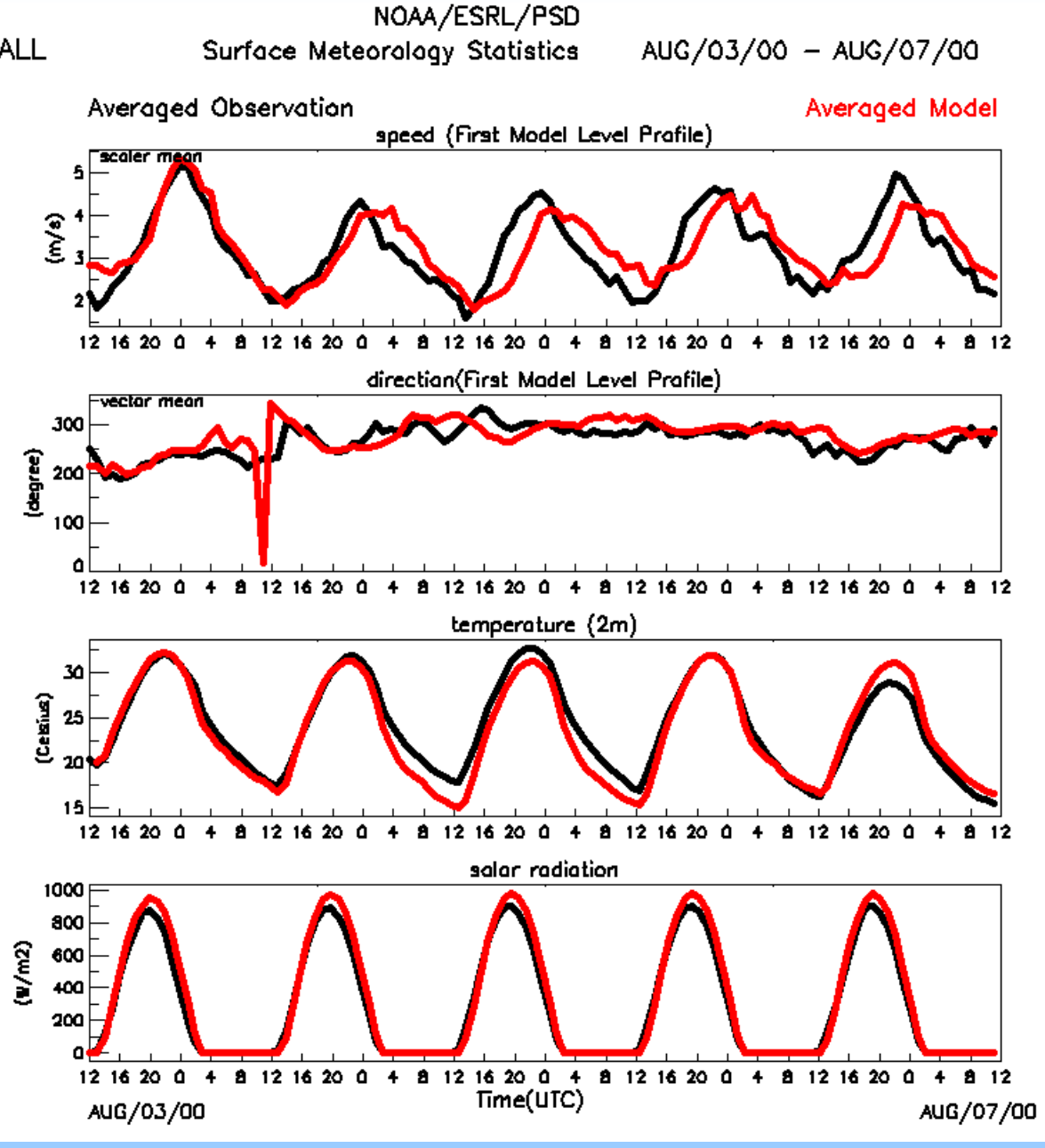

ALL
NOAA/ESRL/PSD
BIAS: MODEL – OBSERVATION
AUG/03/00 – AUG/07/00
BIAS SPEED OF WIND
m/s
5.1
4.0
3.0
2.0
1.0
0.0
−1.0
−2.0
−3.0
−4.0
−5.1
BIAS DIRECTION OF WIND
Degrees
89.6
71.7
53.7
35.8
17.9
0.0
−17.9
−35.8
−53.7
−71.7
−89.6
BIAS TEMPERATURE
Celsius
5.9
4.7
3.5
2.3
1.2
0.0
−1.2
−2.3
−3.5
−4.7
−5.9
Meters
Time UTC
AUG/03/00
AUG/07/00

NOAA/ESRL/PSD

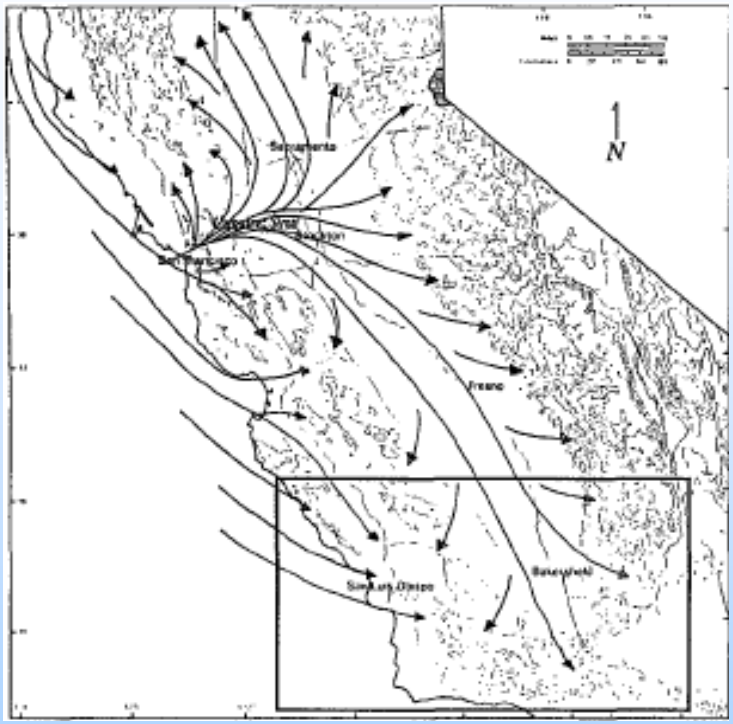
ALL Surface Meteorology Statistics JUL/24/00 – JUL/28/00



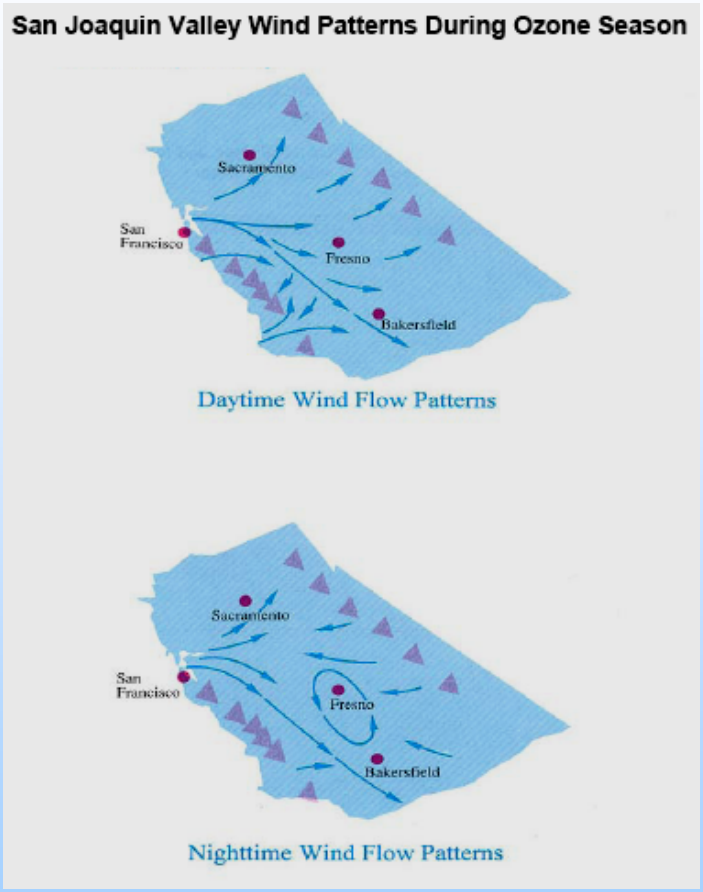

NOAA/ESRL/PSD
ALL
Surface Meteorology Statistics
JUL/29/00 – AUG/02/00
Averaged Observation
Averaged Model
speed (First Model Level Profile)
scaler mean
(m/s)
direction(First Model Level Profile)
vector mean
(degree)
temperature (2m)
(Celsius)
solar radiation
(W/m2)
Time(UTC)
JUL/29/00
AUG/02/00


NOAA/ESRL/PSD
ALL
Surface Meteorology Statistics
AUG/03/00 – AUG/07/00
Averaged Observation
Averaged Model
speed (First Model Level Profile)
scaler mean
(m/s)
direction(First Model Level Profile)
vector mean
(degree)
temperature (2m)
(Celsius)
solar radiation
(W/m2)
Time(UTC)
AUG/03/00
AUG/07/00

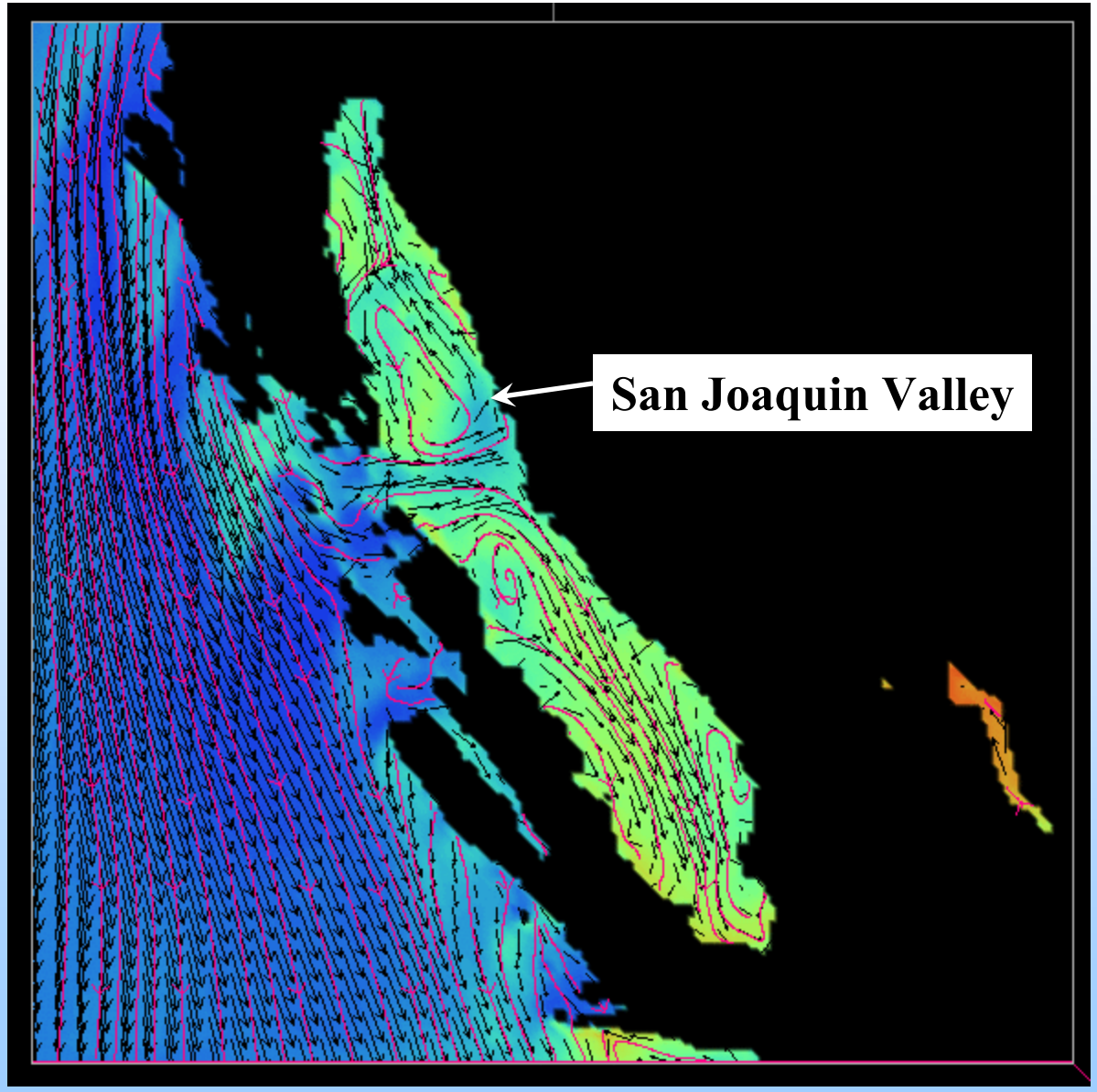
Model Aided Low-Level Wind Analysis



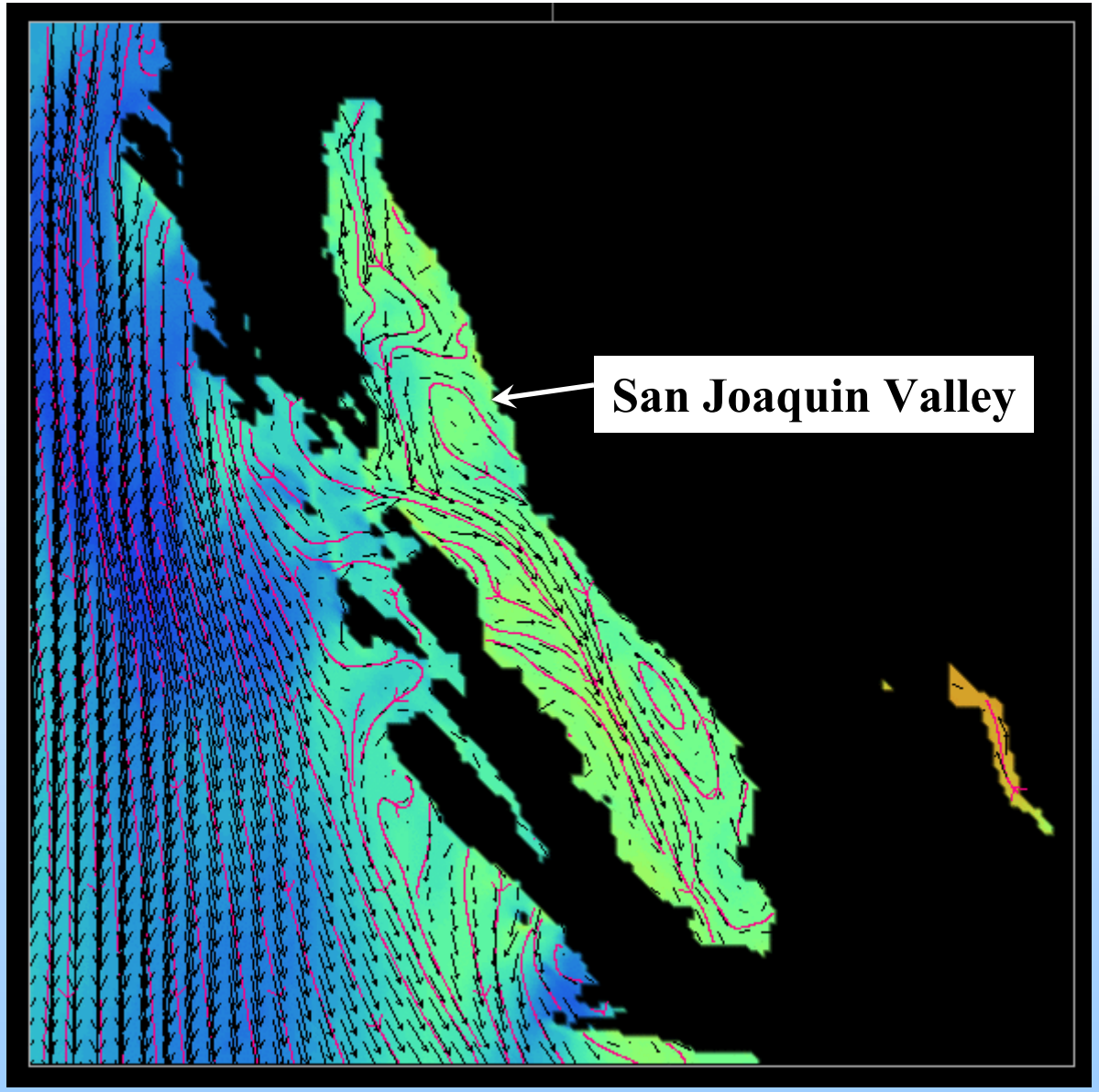
From: Niccum et al. (1995), JAM (originally created by California Air Resources Board).



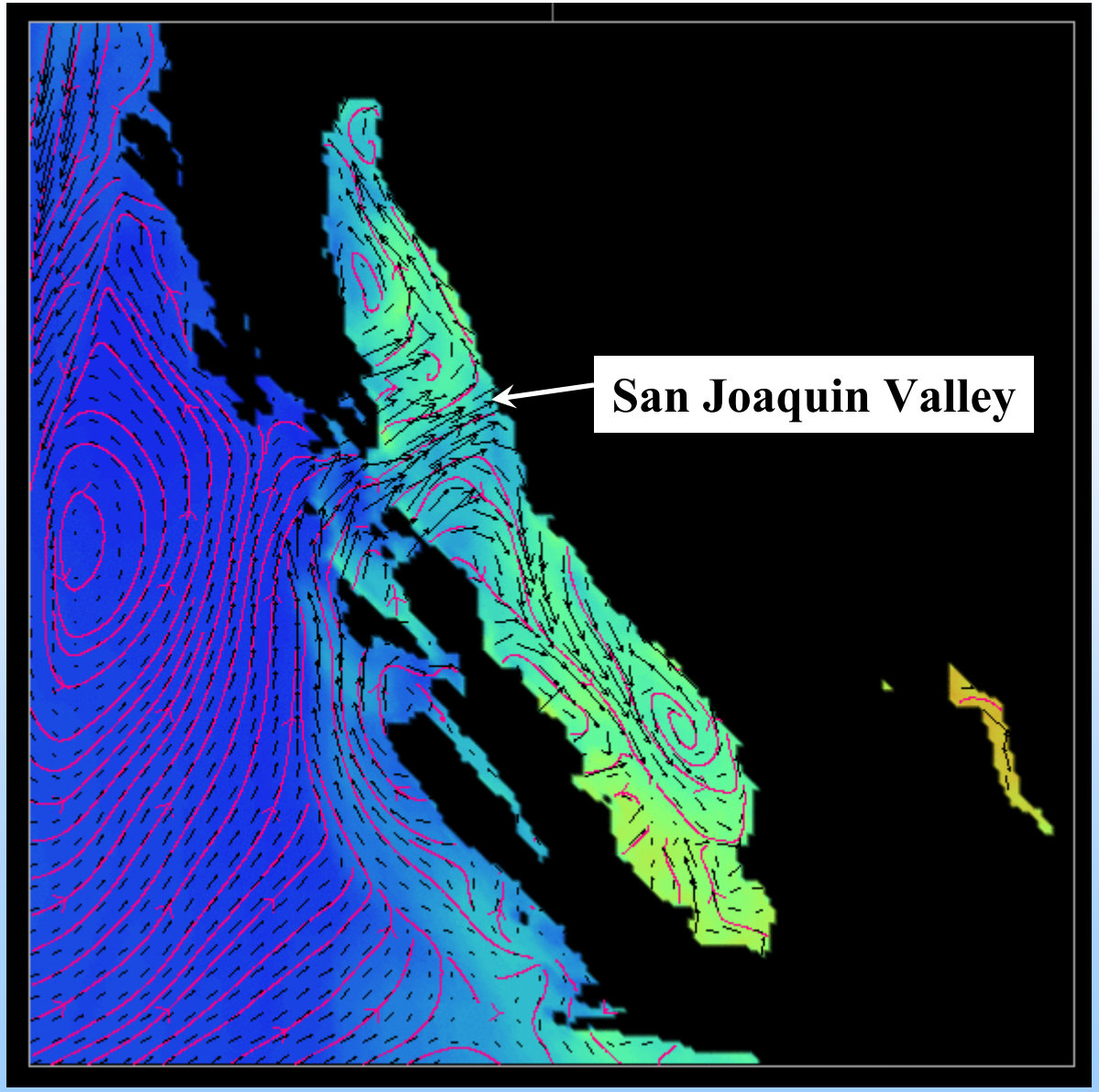
From: "*San Joaquin Valley Air Basin Plan Demonstrating Attainment Of Federal 1-hour Ozone Standards*", by San Joaquin Valley Air Pollution Control District, October 8, 2004.



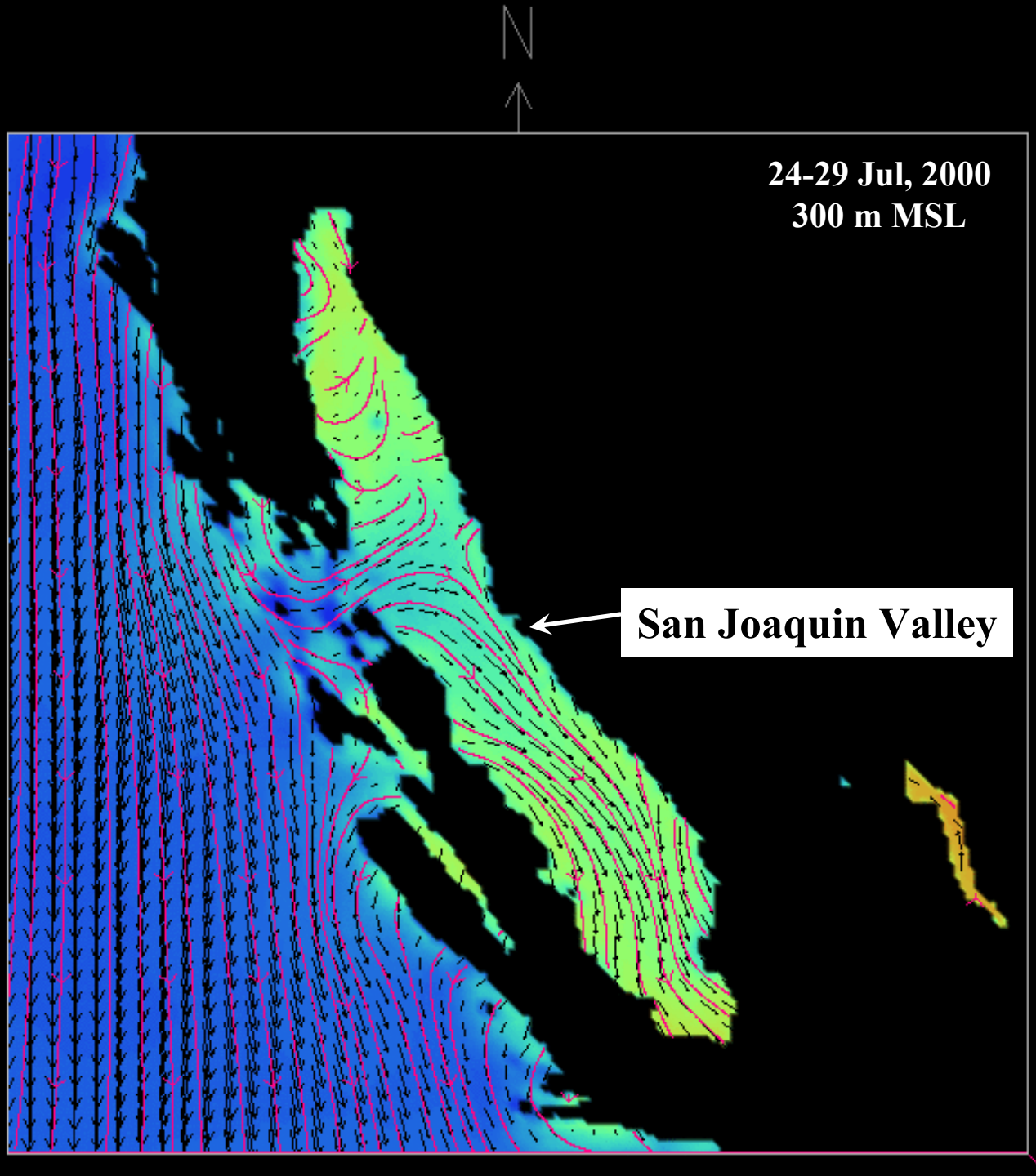
1000 UTC July 25, 2000

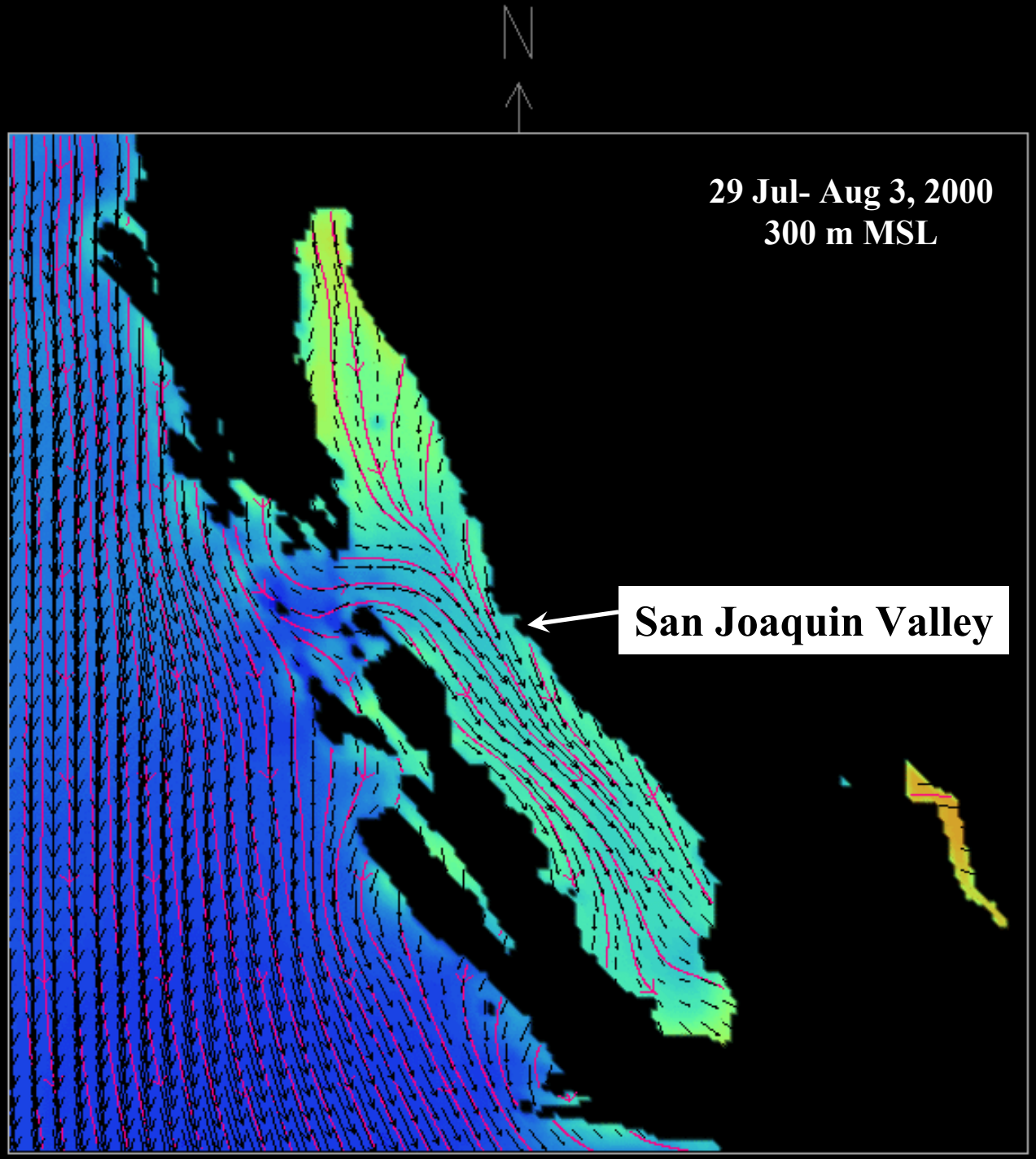


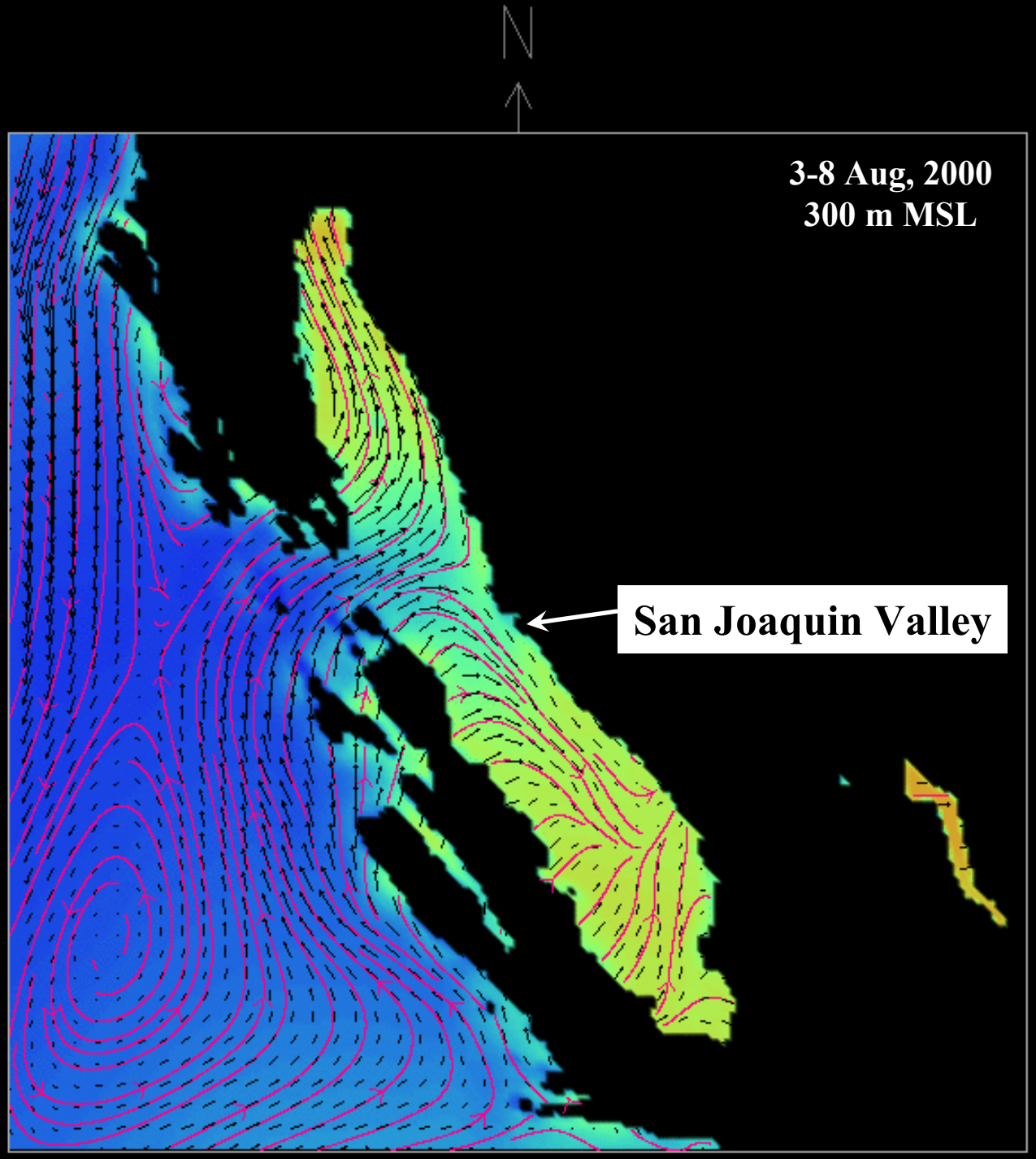
1400 UTC July 30, 2000

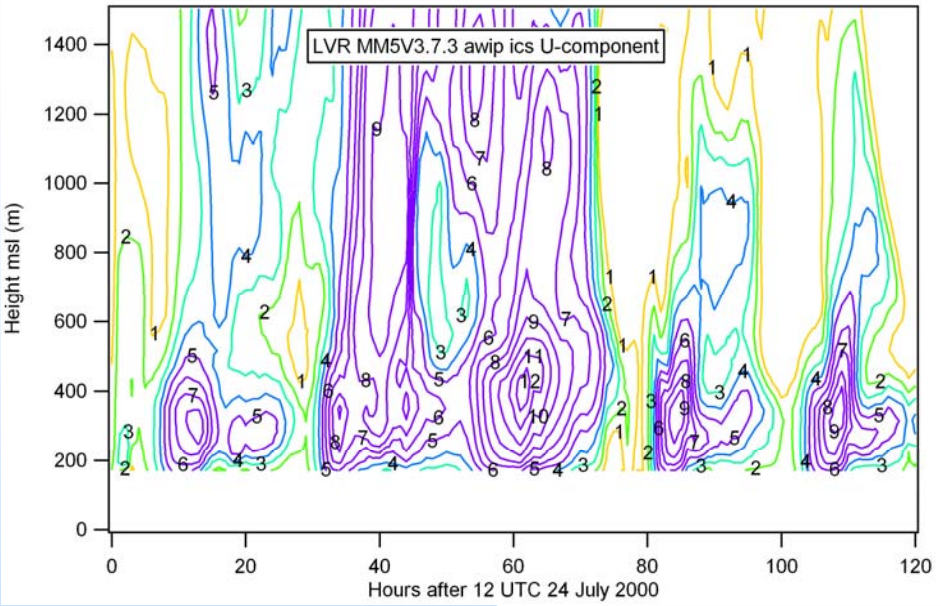


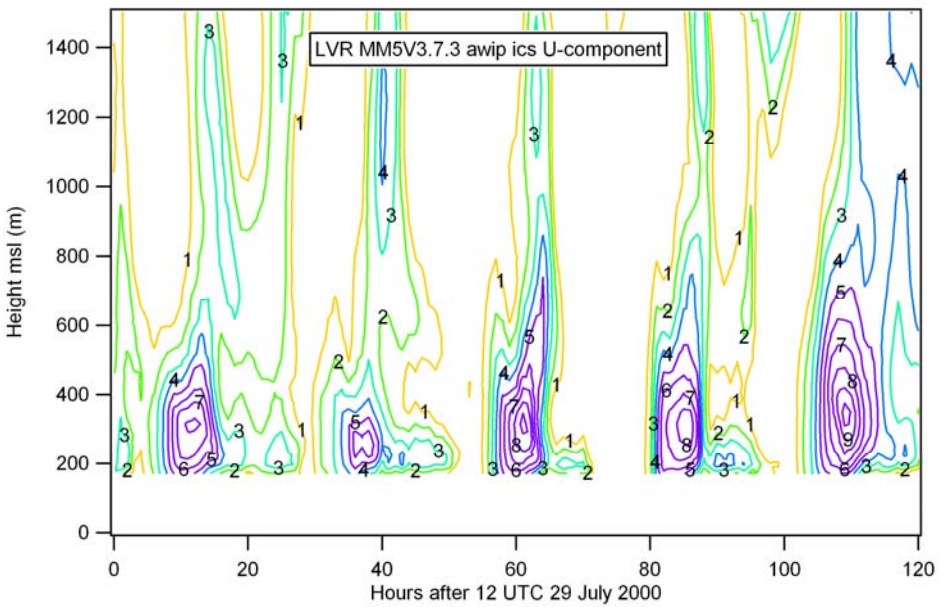
1100 UTC Aug 4, 2000


N
24-29 Jul, 2000
300 m MSL
San Joaquin Valley

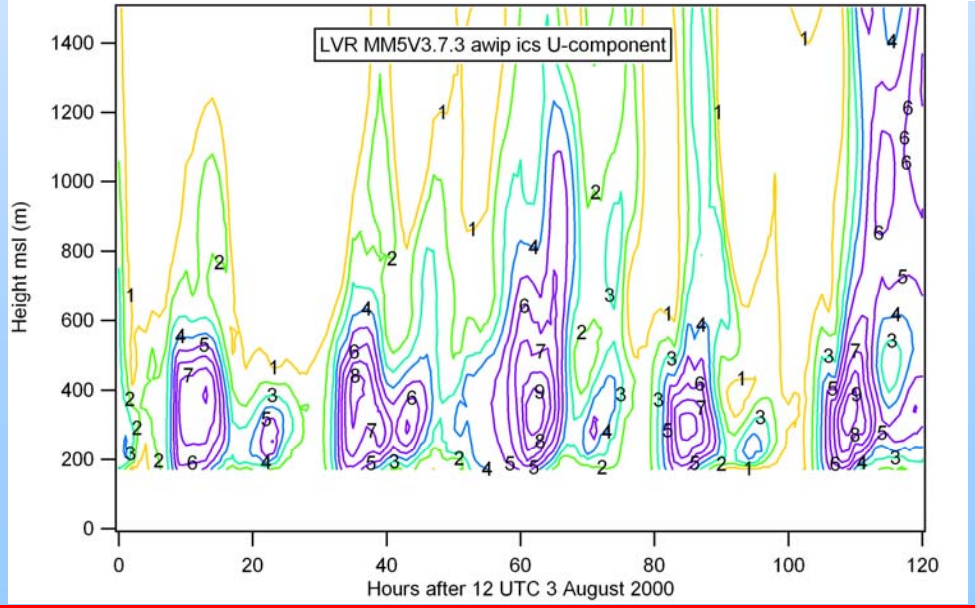

N
29 Jul- Aug 3, 2000
300 m MSL
San Joaquin Valley


N
3-8 Aug, 2000
300 m MSL
San Joaquin Valley





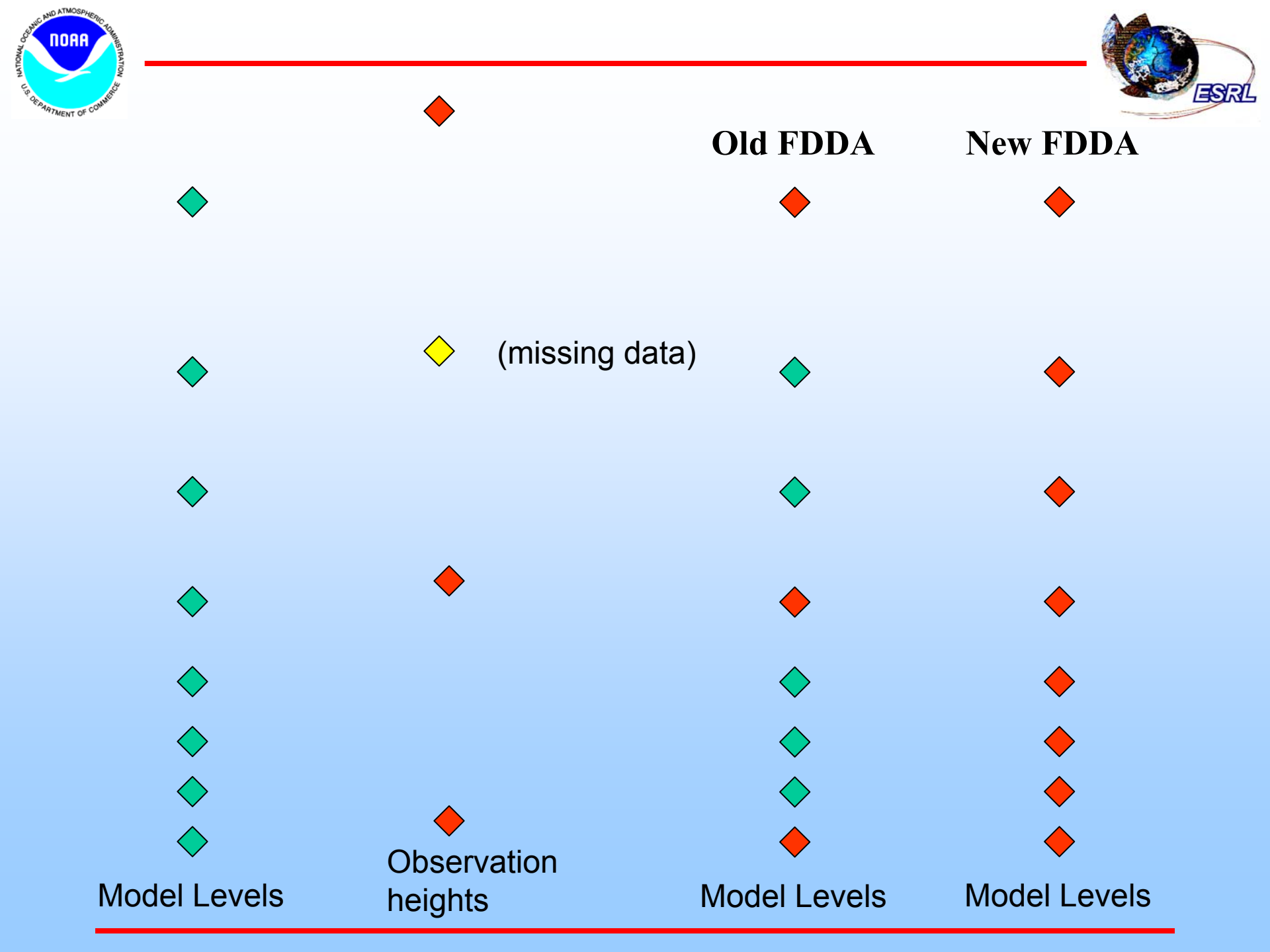
U-component wind at Livermore



IMPROVEMENTS TO THE MODEL: FDDA

- Original FDDA: each observation only nudged a single model layer, the closest to the observation height

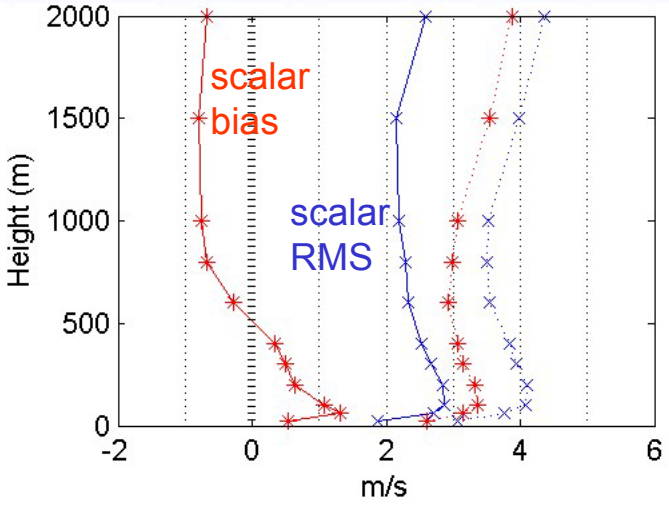
- New FDDA linearly interpolates between profiler levels and surface winds and nudges every model level in the range of data.

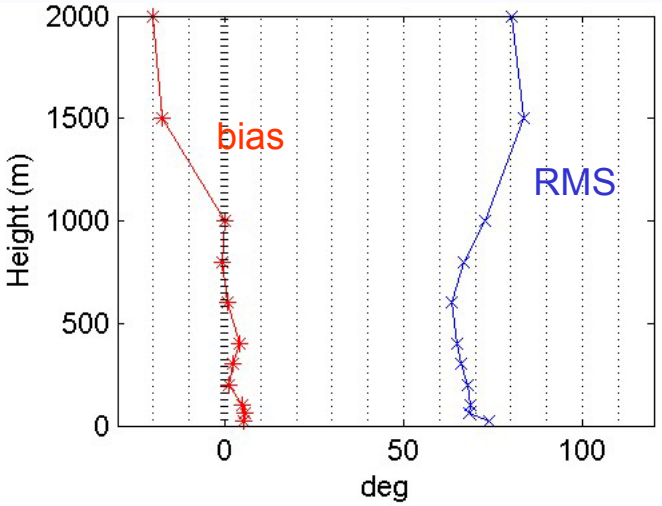

Old FDDA
New FDDA
(missing data)
Model Levels
Observation heights
Model Levels
Model Levels

Speed

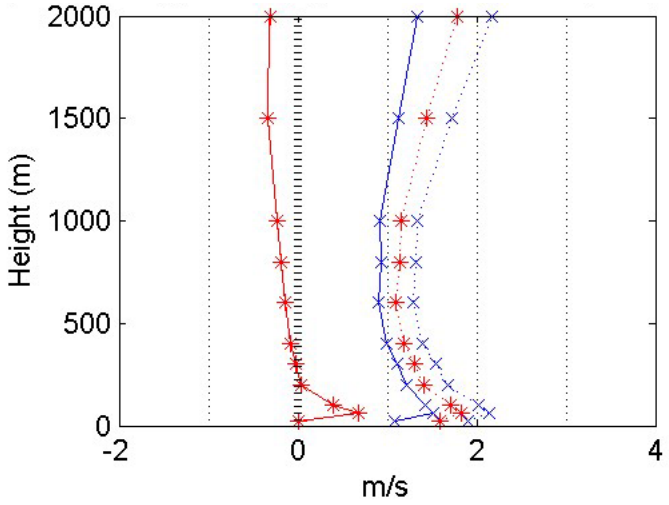
Direction

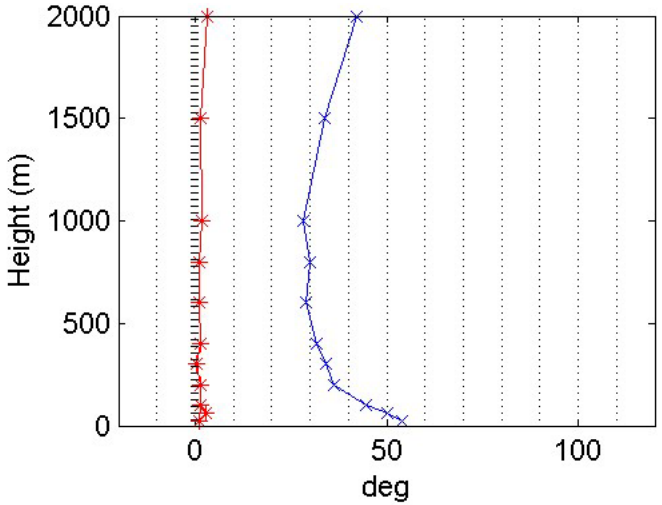
MM5,
No FDDA





Old
FDDA



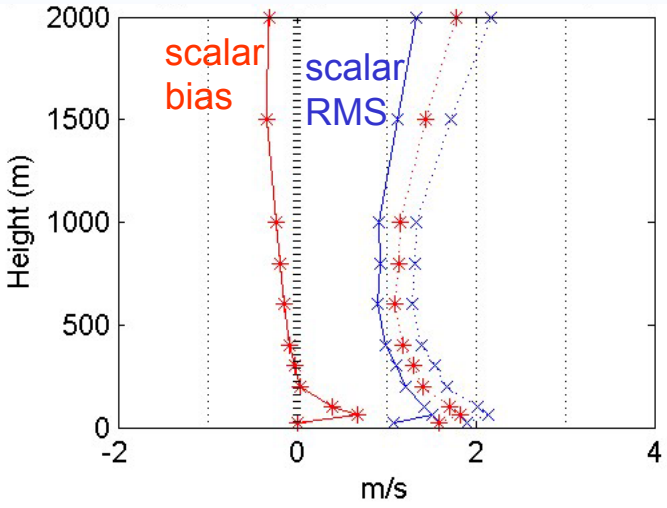


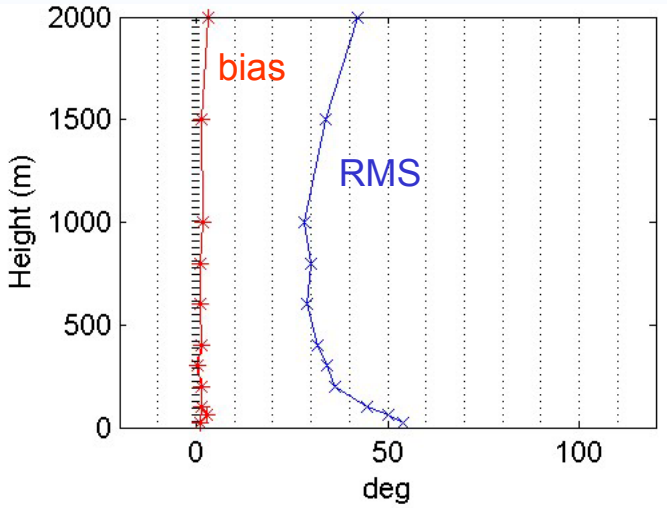
Speed

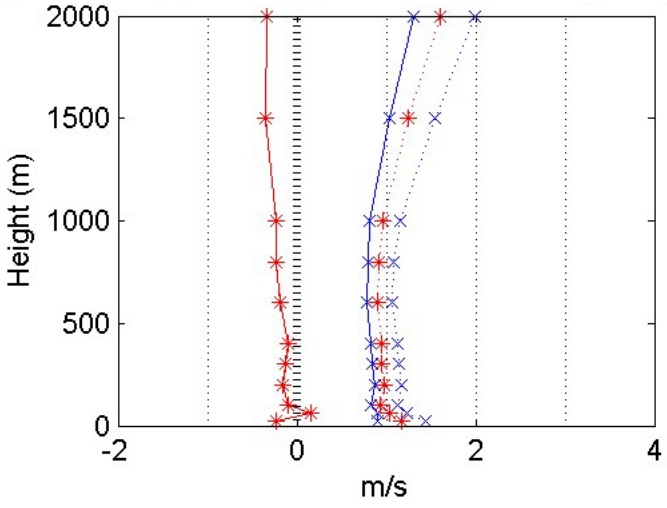
Direction

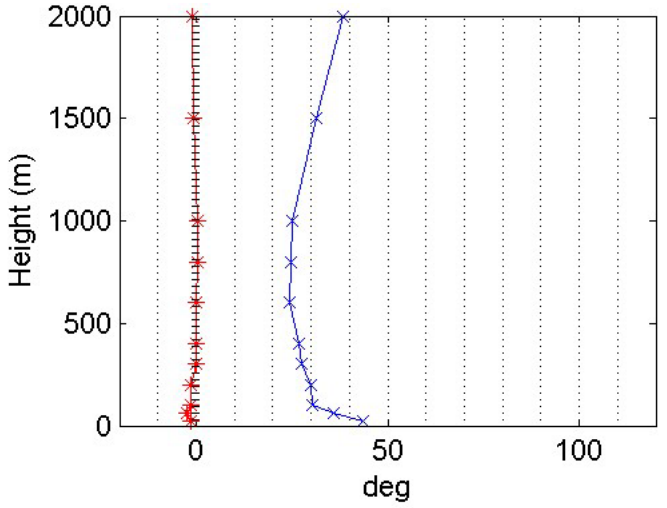
Old FDDA

New FDDA









CONCLUSIONS

- The model reproduces reasonably well the observed wind and temperature in the lower troposphere.

- The diurnal cycle in the model simulated surface wind and temperature agrees well with that revealed in the observations. However,
  -- the model temperature diurnal cycle amplitude is slightly larger than observed;
  -- low-level nocturnal jet is stronger in the model than observed

CONCLUSIONS

- The simulated short-wave radiation overall agrees with the observations, with small magnitude differences caused by the errors in simulated clouds.

- Variation in the background flow leads to differences in the intensity of the incoming flow through the SF Bay area, and leads to differences in the upslope/downslope flows and the formation of eddies in the central Valley.

- The improved FDDA effectively reduces the bias and RME error in the low-level winds.

Future Work

- Expand the simulation to the entire summer 2000.
- Classify various flow regimes and examine how the performance of the model varies with different regimes.
- Compare the simulated and observed transport processes using the ESRL newly developed wind profiler trajectory tool.

The NOAA/ESRL wind profiler trajectory tool web interface

NEAQS 2004

User's Guide
Trajectory Library

Start trajectory from:

Chebouge, NS (CBE)
or specify:
lat: 43.7 lon: -66.1

Start Date (UTC)

11 Aug 2004

Start Time (UTC) 0:00

Time Steps: 36 hours

Direction: Backward

Select Profilers

- ADI
- BHB
- CBE
- CCD
- DAL
- PEA
- PIT
- PYM
- RUT
- STO
- RHB
- Surface

Specify Altitudes

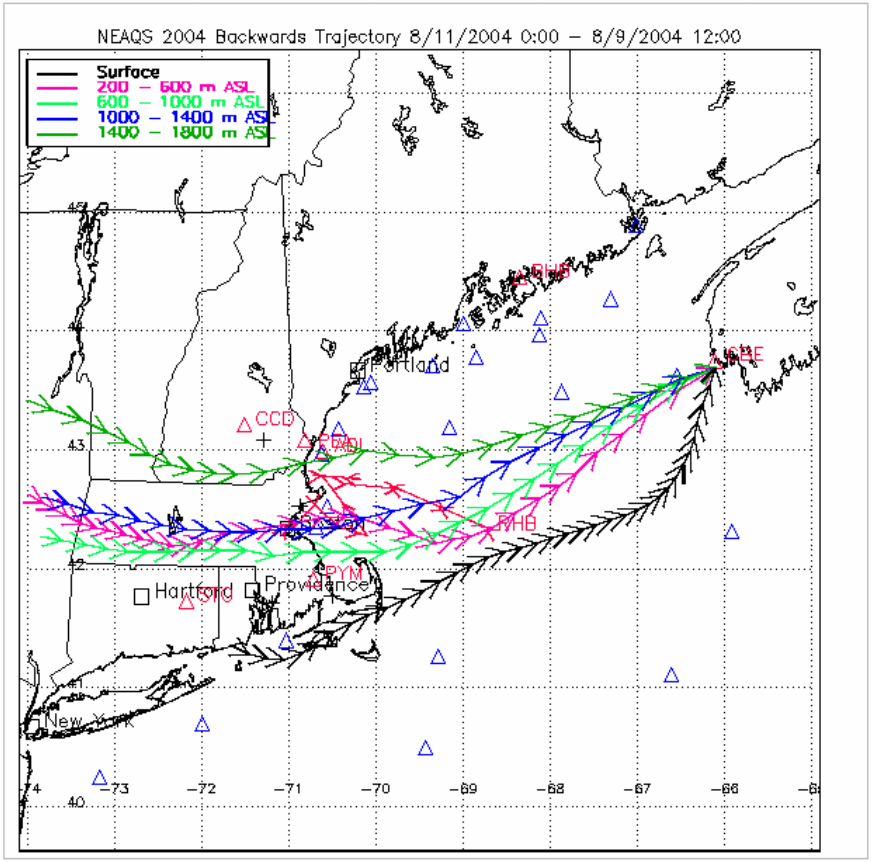
Color	Min Alt (km-msl)	Max Alt (km-msl)
magenta	200	600
cyan	600	1000
blue	1000	1400
green	1400	1800

Plot Lat/Lon Range

N Lat 46.3
W Lon -74.0
E Lon -65.0
S Lat 39.7

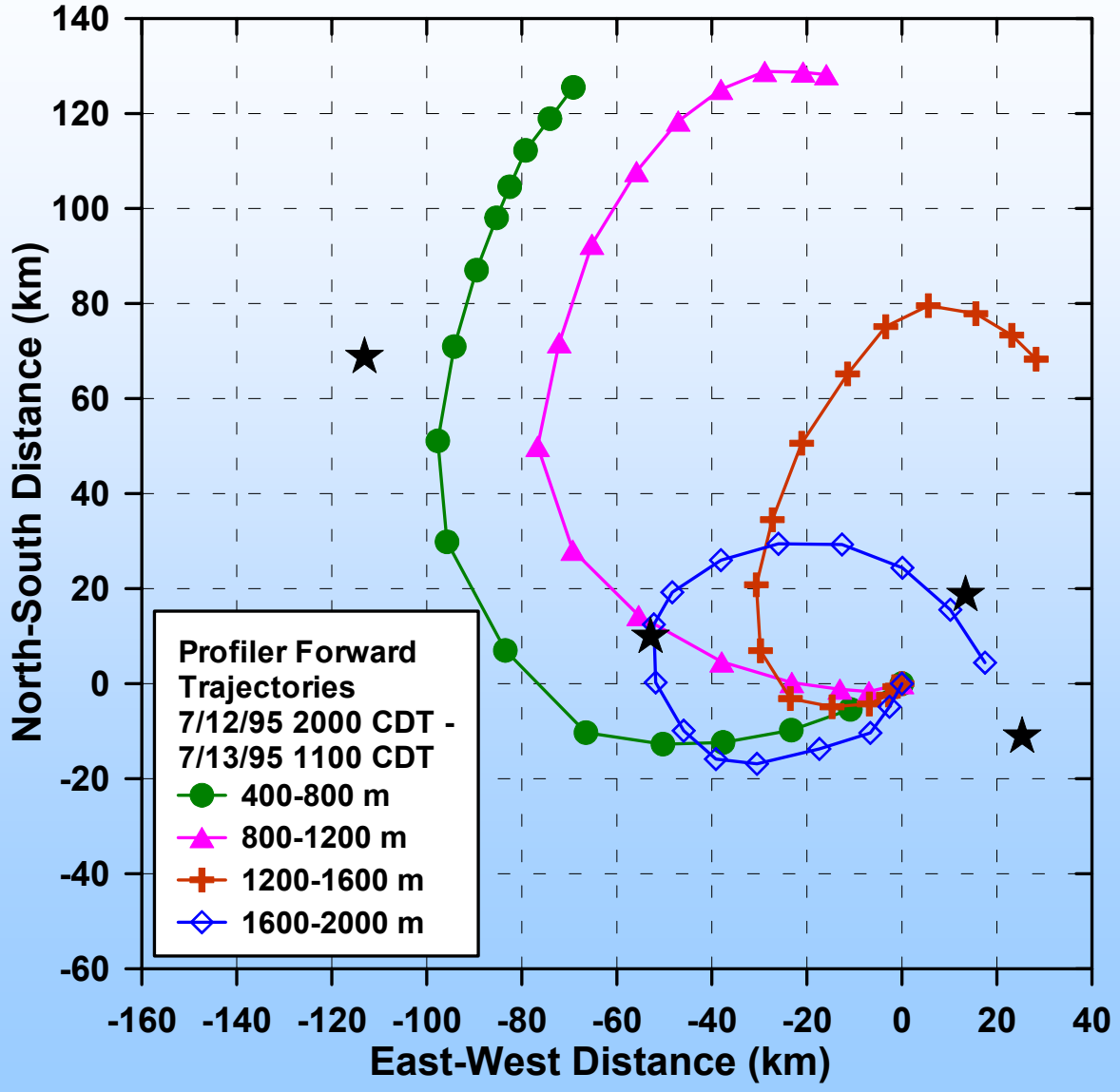
Submit

Trajectory Map Plot | Printable Map Plot | Profiler Statistics | ASCII Trajectory Data | Evaluation

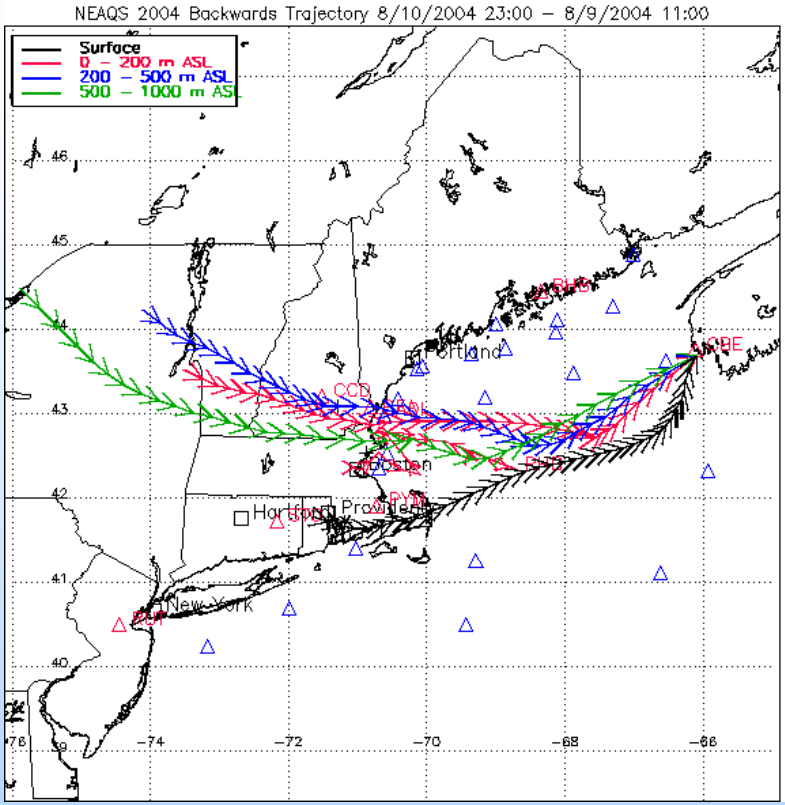


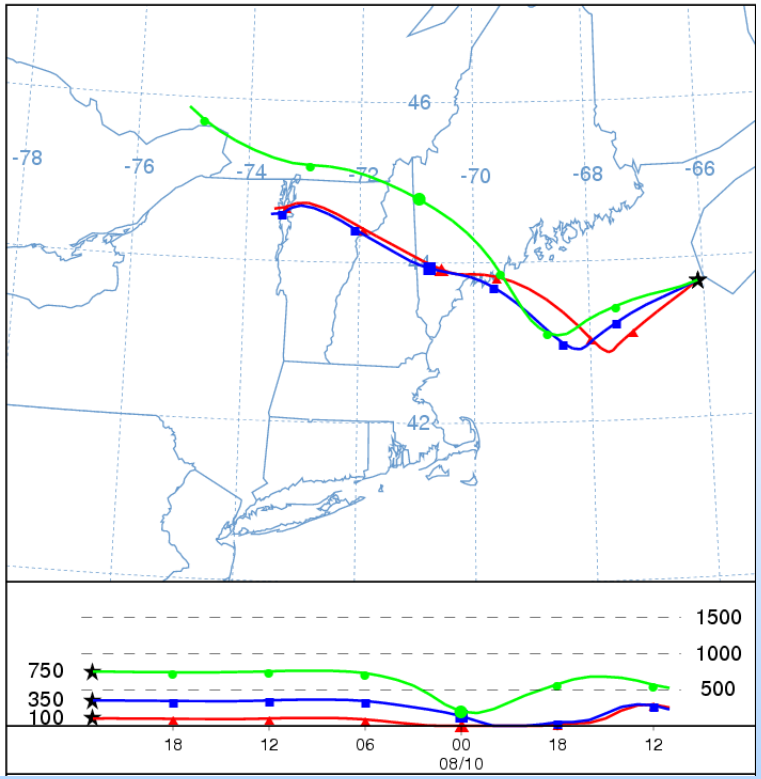
The NOAA/ESRL wind profiler trajectory tool

Results from the 1995 Southern Oxidants Study showed that the regional transport of pollutants could be explained using trajectories calculated from wind profiler networks (profiler locations marked by stars). This example shows how the Nashville urban plume formed during the day is redistributed at night, and demonstrates the combined impacts of a nocturnal low-level jet and the inertial oscillation on regional transport.



The NOAA/ESRL wind profiler trajectory tool





For the 2004 New England Air Quality Study, back trajectories were run using profiler data and using the NOAA HYSPLIT trajectory model, which in this case used the 40 km gridded data from the Eta data assimilation system (EDAS). Since the cornerstone of the operational upper-air wind observing system are the 0000 and 1200 UTC rawinsondes, the HYSPLIT trajectories fail to show the impact of a warm front that passed through the northeast between sounding times. The trajectories based on hourly profiler data capture this change and more accurately reflect the source region of pollution reaching Nova Scotia at this time.