MM5 Meteorological Simulations of the Central California Ozone Study

Jian-Wen Bao, Sara Michelson, Ola Persson

Jim Wilczak
NOAA/Earth System Research Laboratory

(with input from Don Lehrman)

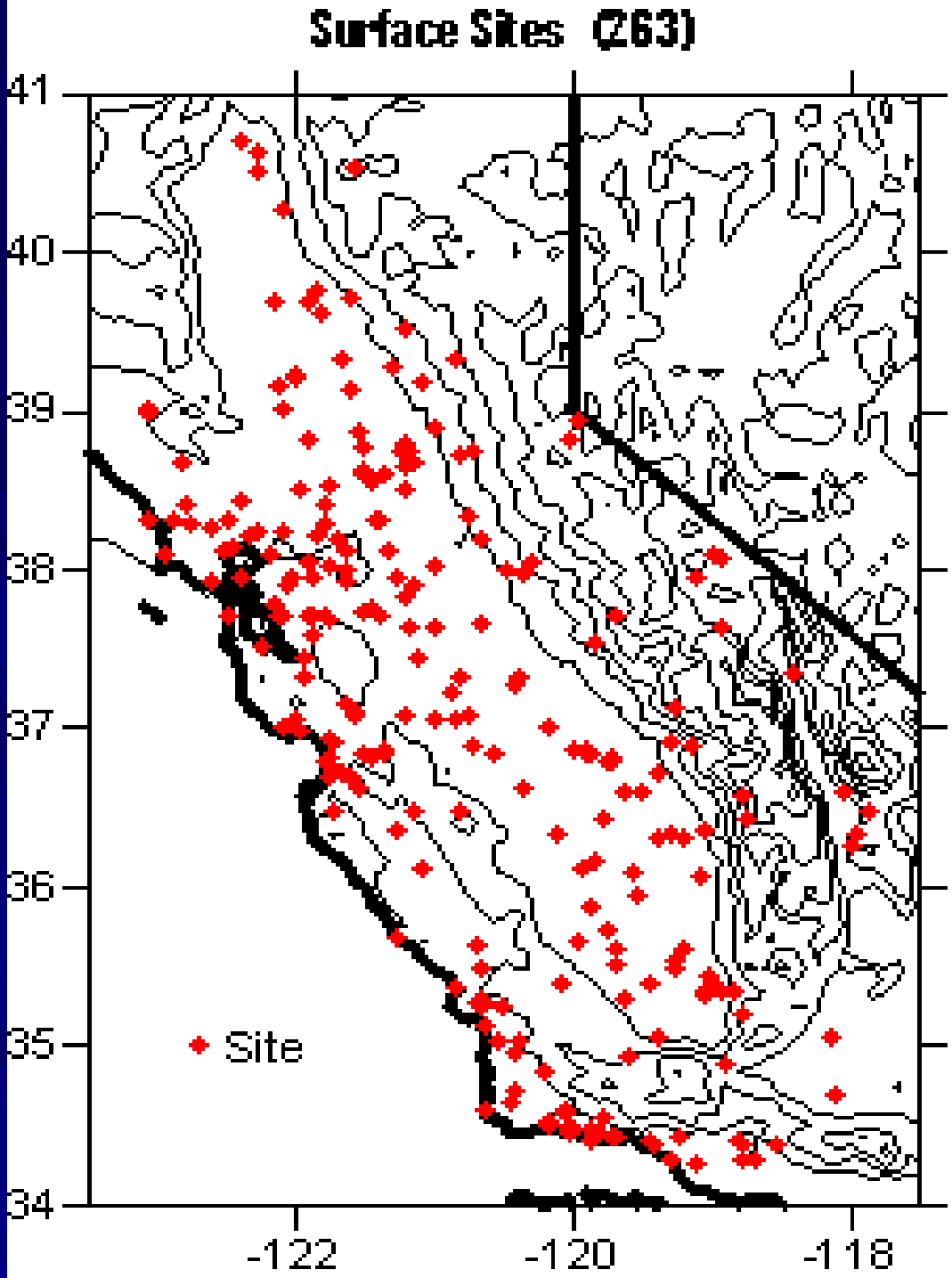
23 June 2006

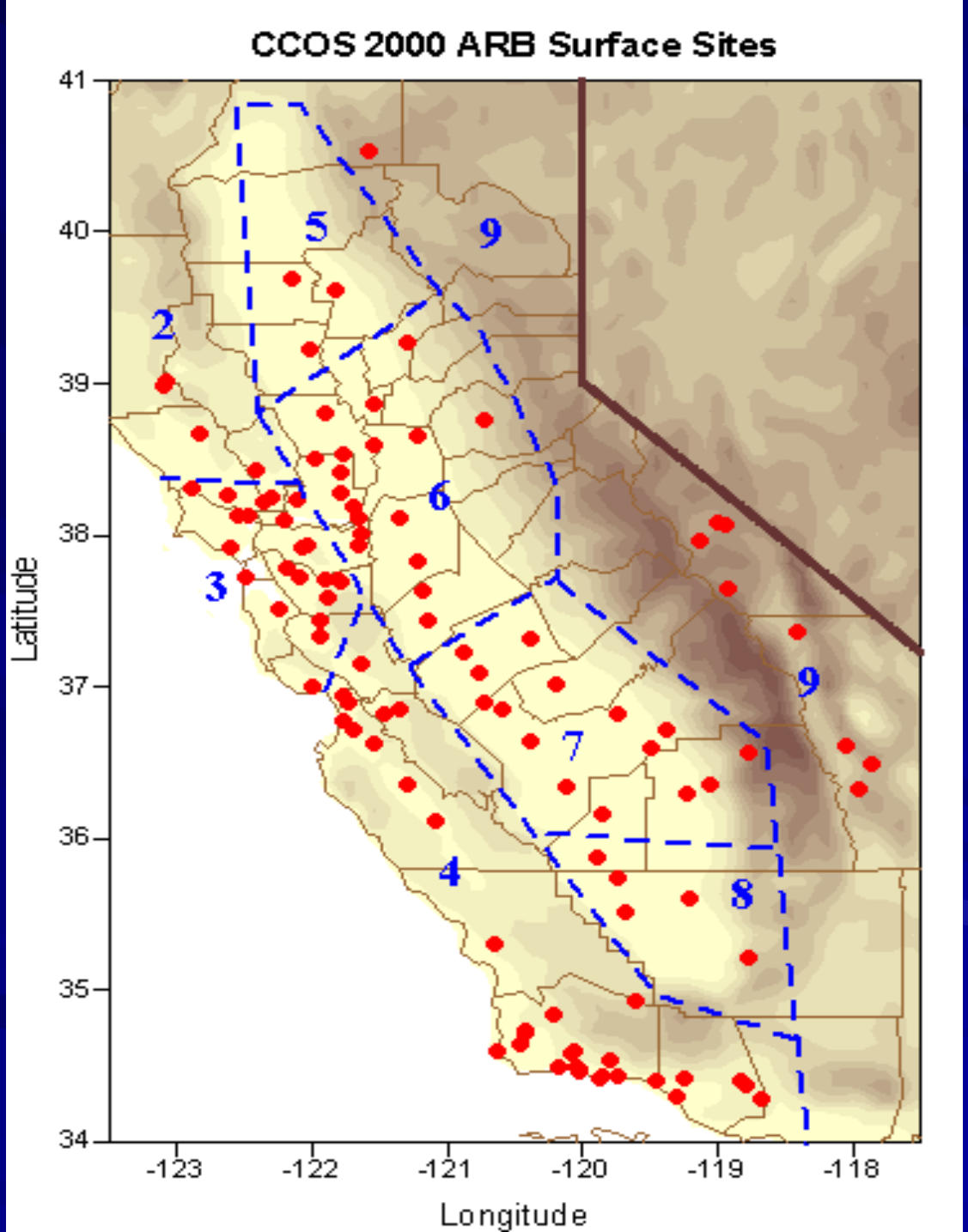
Instrumentation

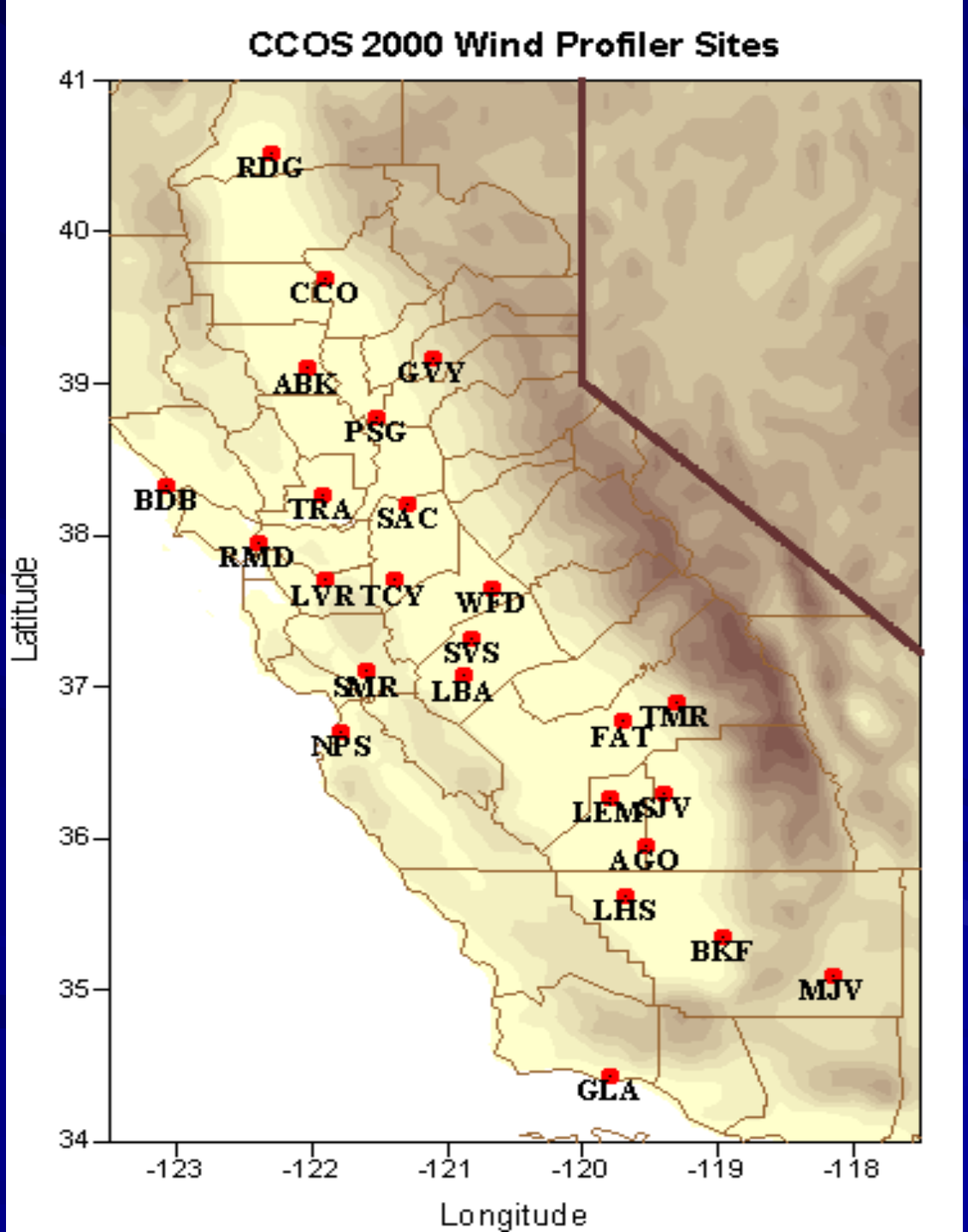
- 25 wind profilers with RASS
- 14 NOAA solar and net radiation sites
- 263 surface met stations

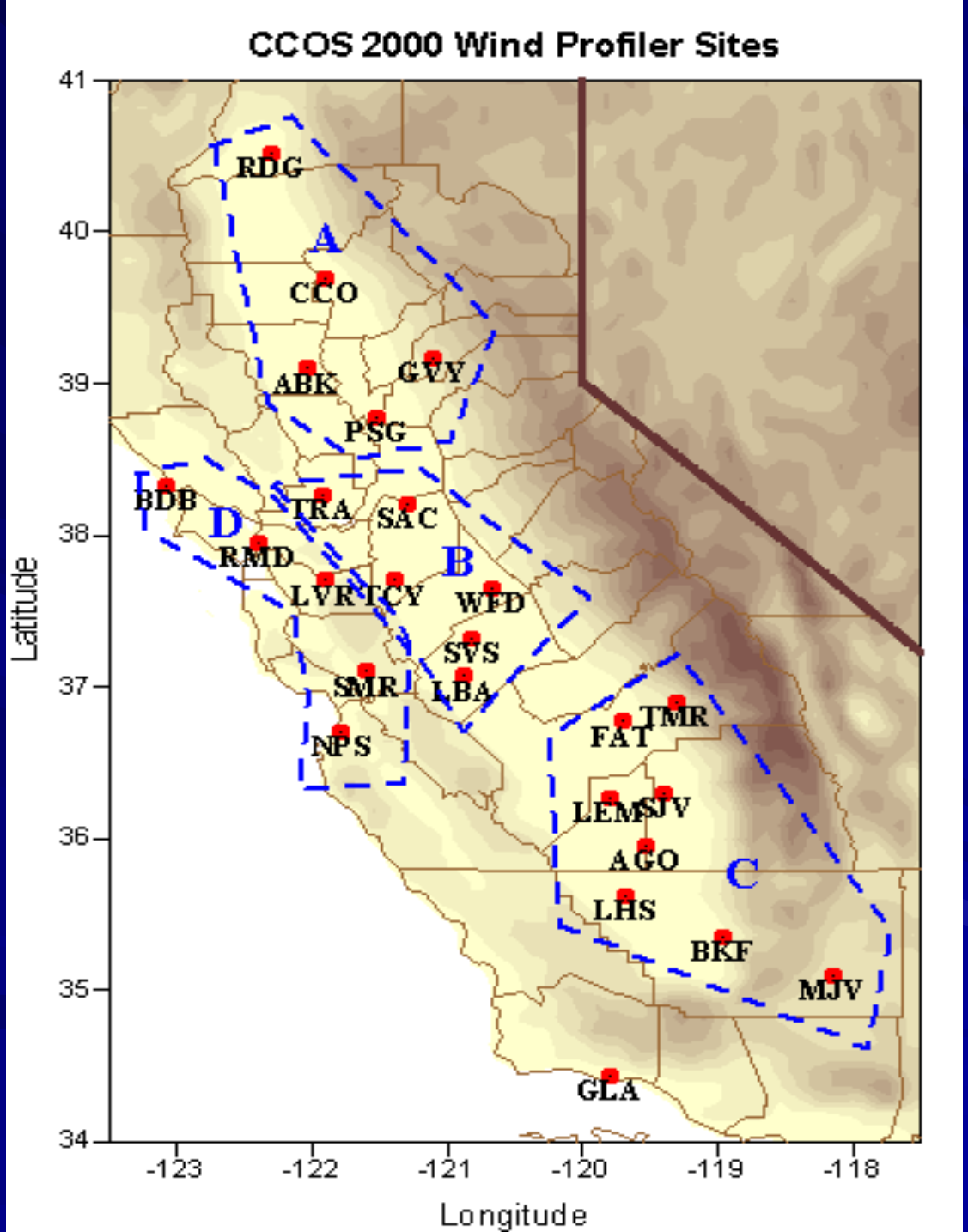
Experiment Dates

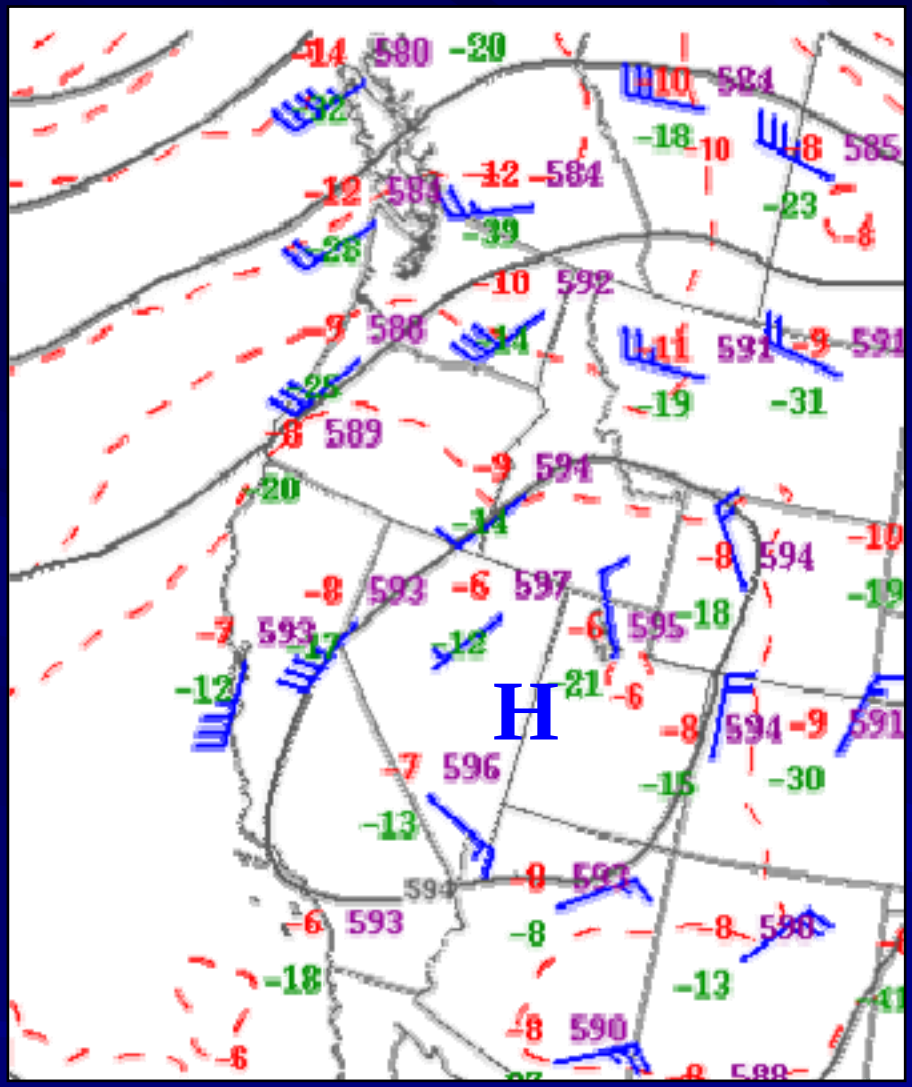
- June-Sept 2000
- IOP2: 29 July – August3


Surface Sites (263)
41
40
39
38
37
36
35
34
-122
-120
-118
Site

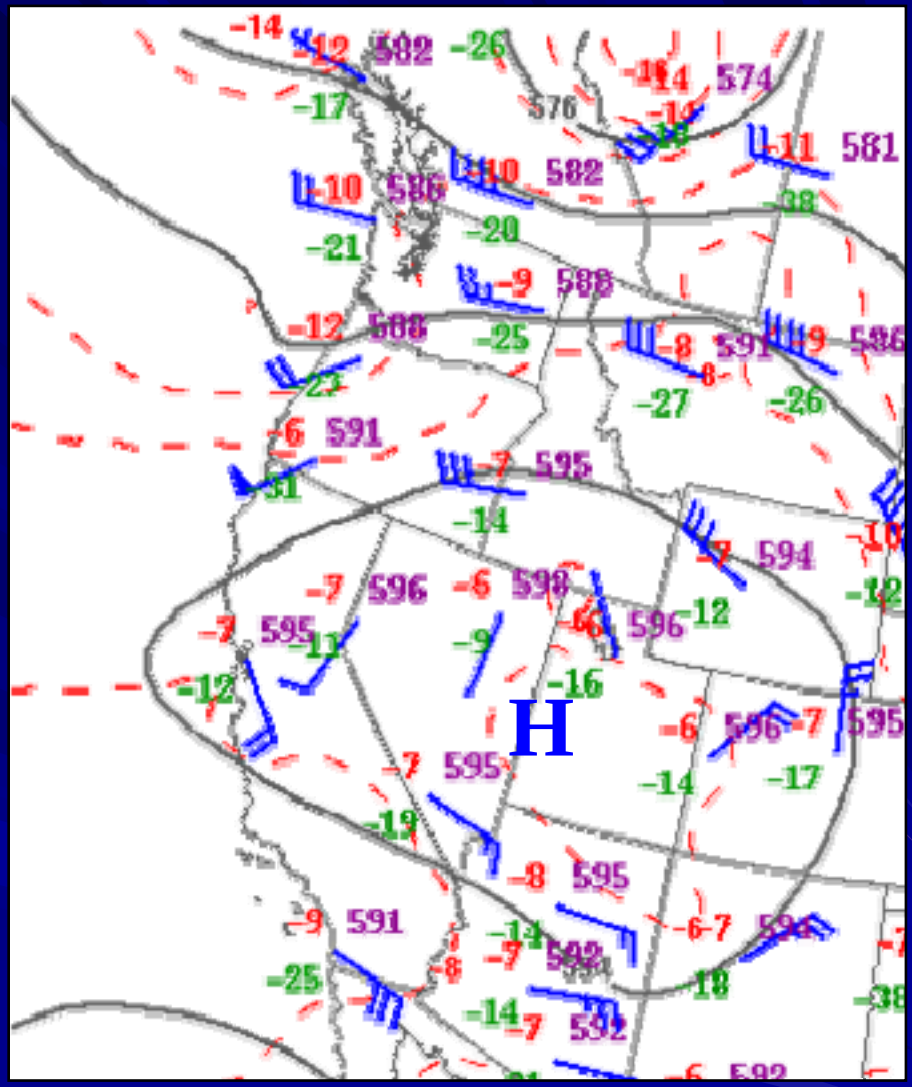

CCOS 2000 ARB Surface Sites
41
40
39
38
37
36
35
34
Latitude
-123
-122
-121
-120
-119
-118
Longitude
2
3
4
5
6
7
8
9
9


CCOS 2000 Wind Profiler Sites
RDG
CCO
ABK
GVY
PSG
BDB
TRA
SAC
RMD
LVR
TCY
WFD
SVS
SMR
LBA
TMR
FAT
NPS
LEM
SJV
AGO
LHS
BKF
MJV
GLA
41
40
39
38
37
36
35
34
Latitude
-123
-122
-121
-120
-119
-118
Longitude


CCOS 2000 Wind Profiler Sites
RDG
A
CCO
ABK
GVY
PSG
BDB
TRA
SAC
D
RMD
B
LVR
TCY
WFD
SVS
SMR
LBA
NPS
TMR
FAT
LEM
SJV
AGO
C
LHS
BKF
MJV
GLA
41
40
39
38
37
36
35
34
Latitude
-123
-122
-121
-120
-119
-118
Longitude



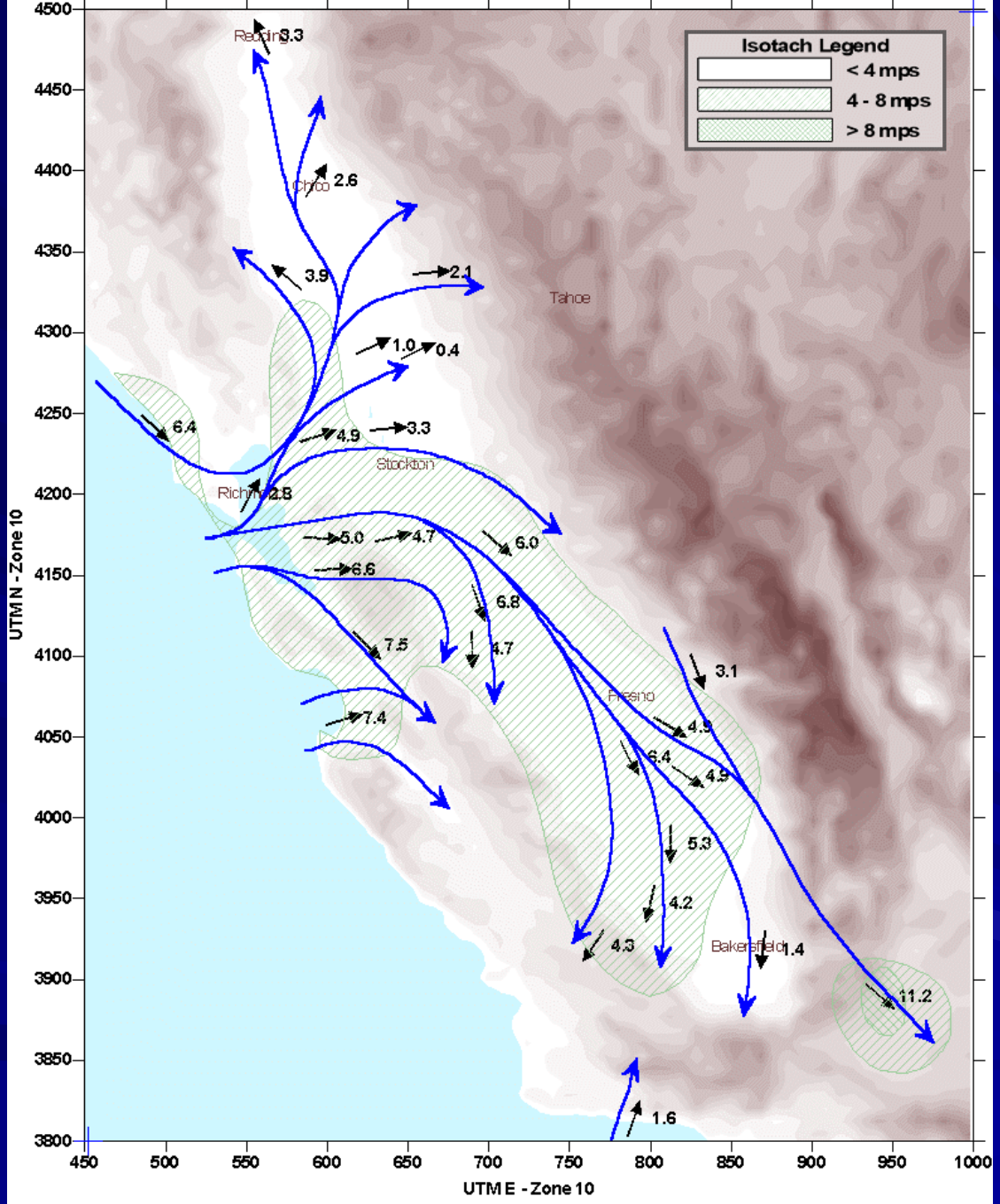
7/30/00



8/01/00

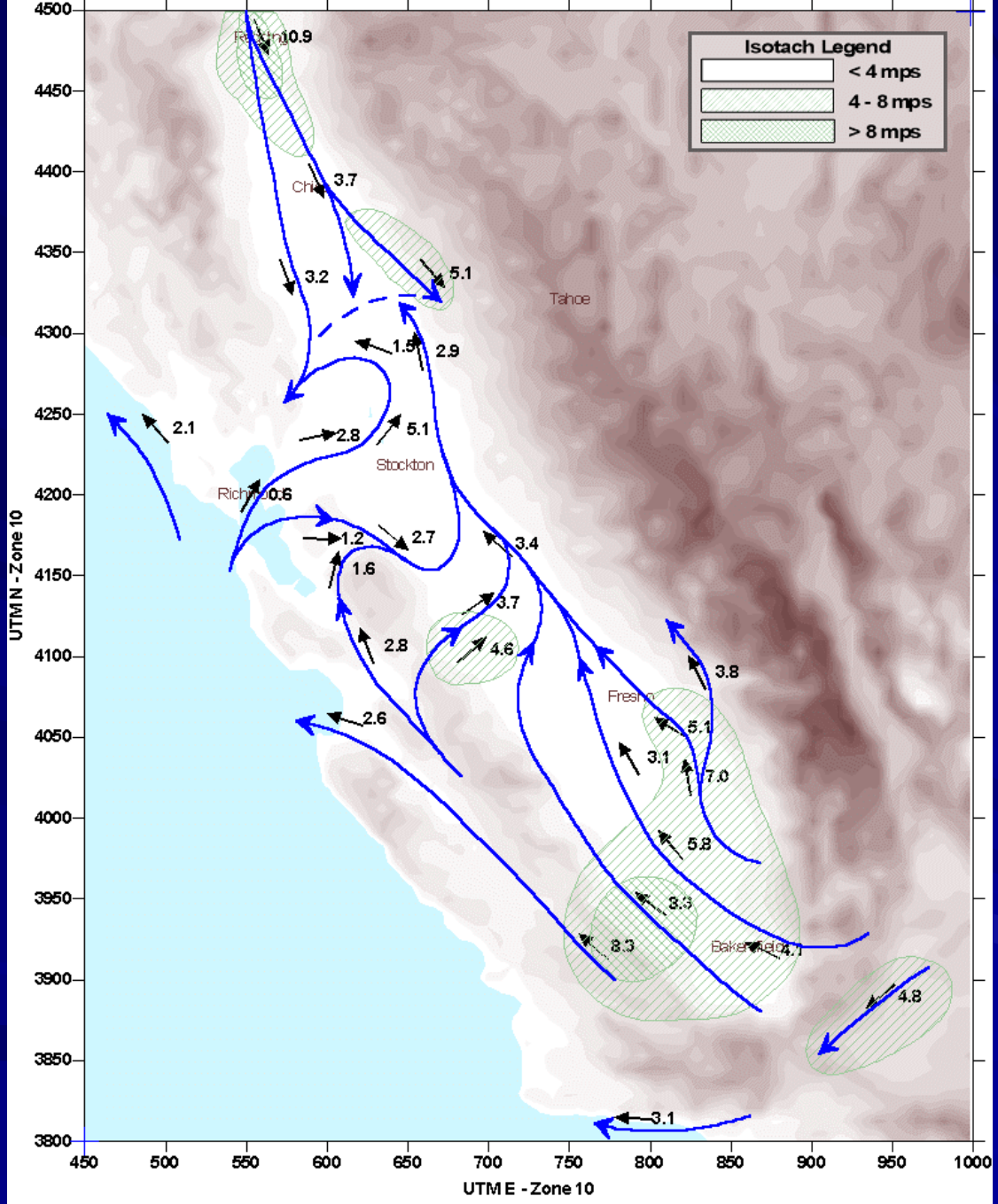
500 mb Constant Pressure Charts, 00 UTC for July 28 and 30 and August 1, 2000

16 PST
30 July 2000



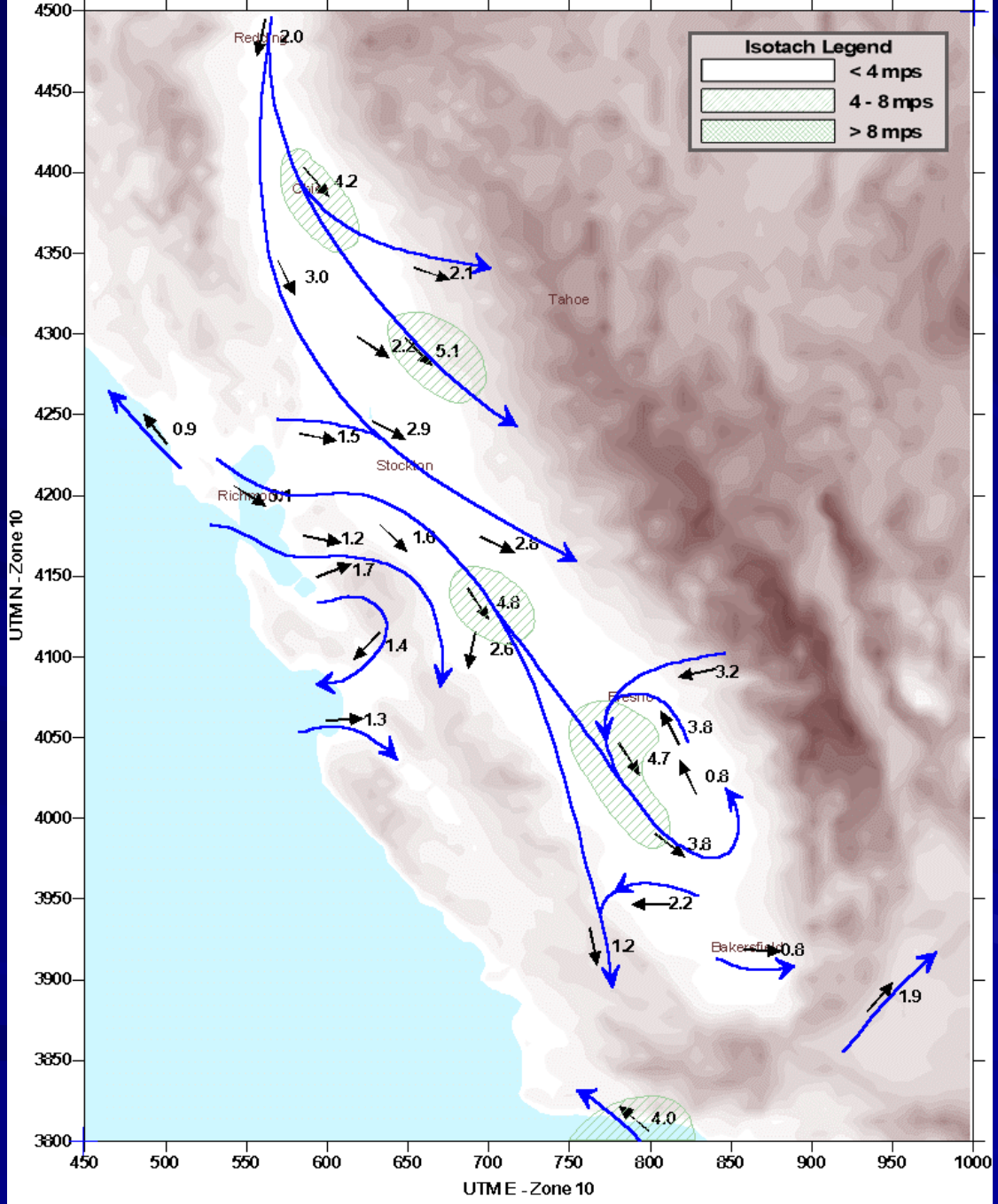
200 Meter Winds on July 30, 2000 at 16 PST

04 PST
01 Aug 2000

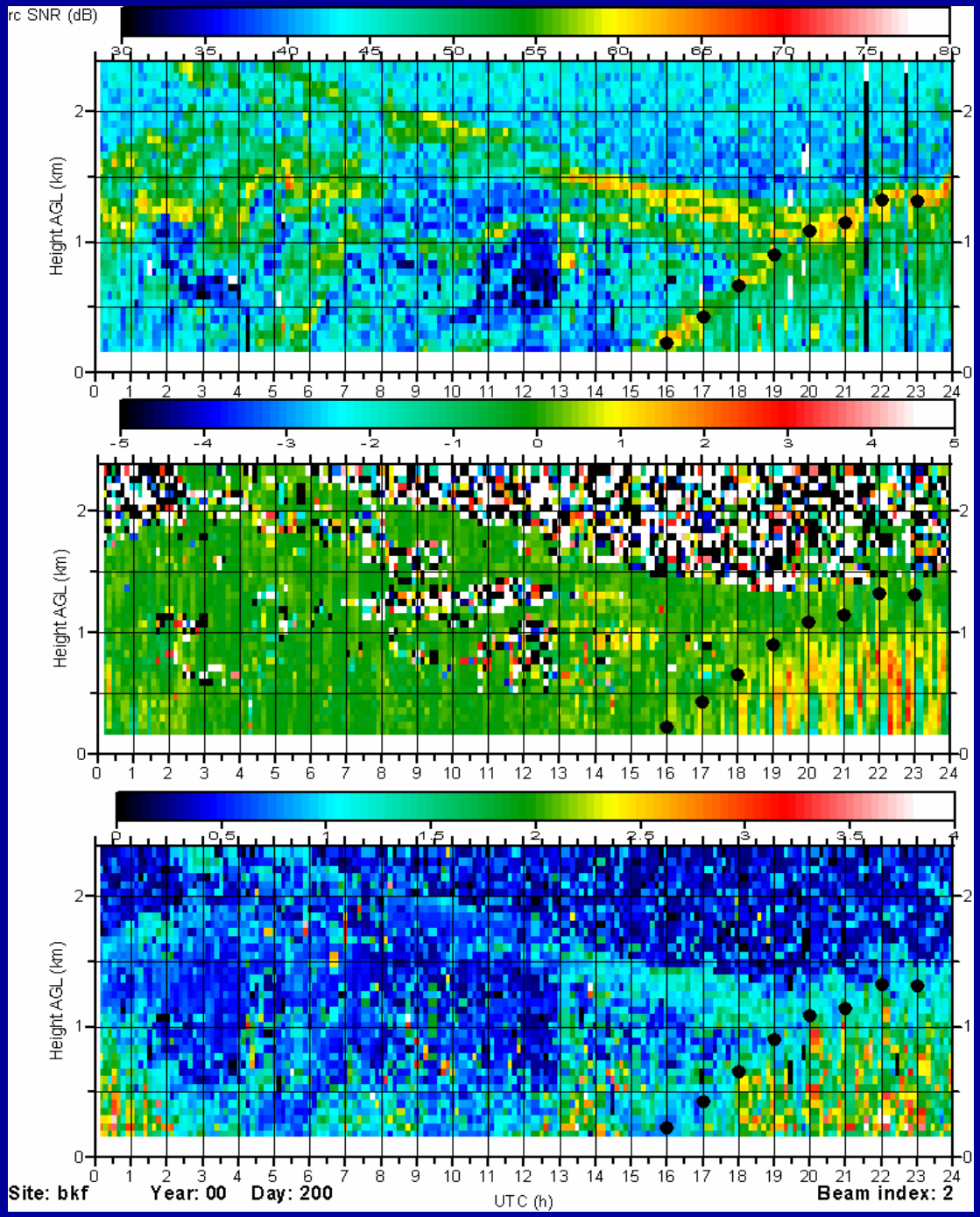


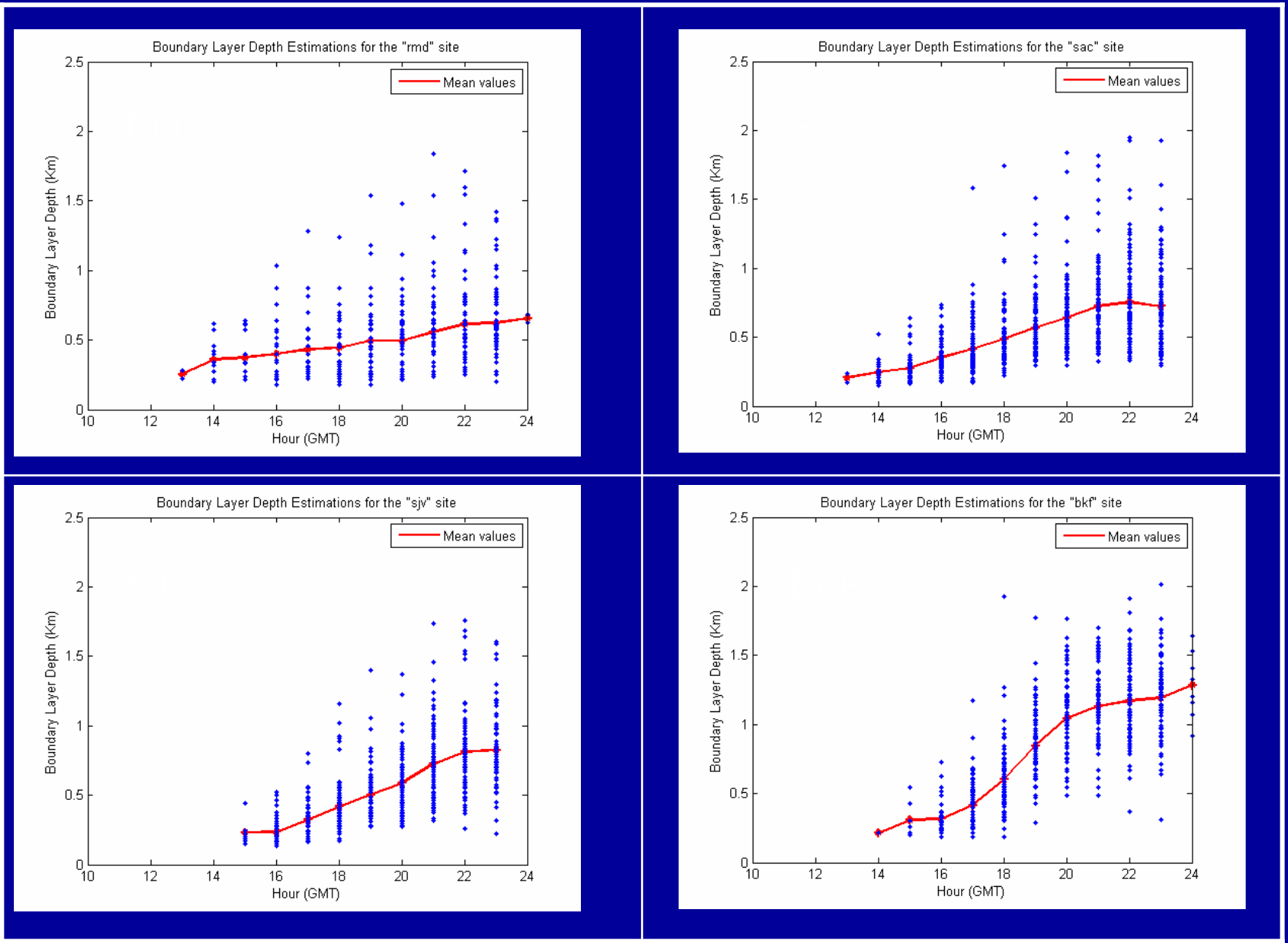
200 Meter Winds on August 01, 2000 at 04 PST

10 PST
31 July 2000

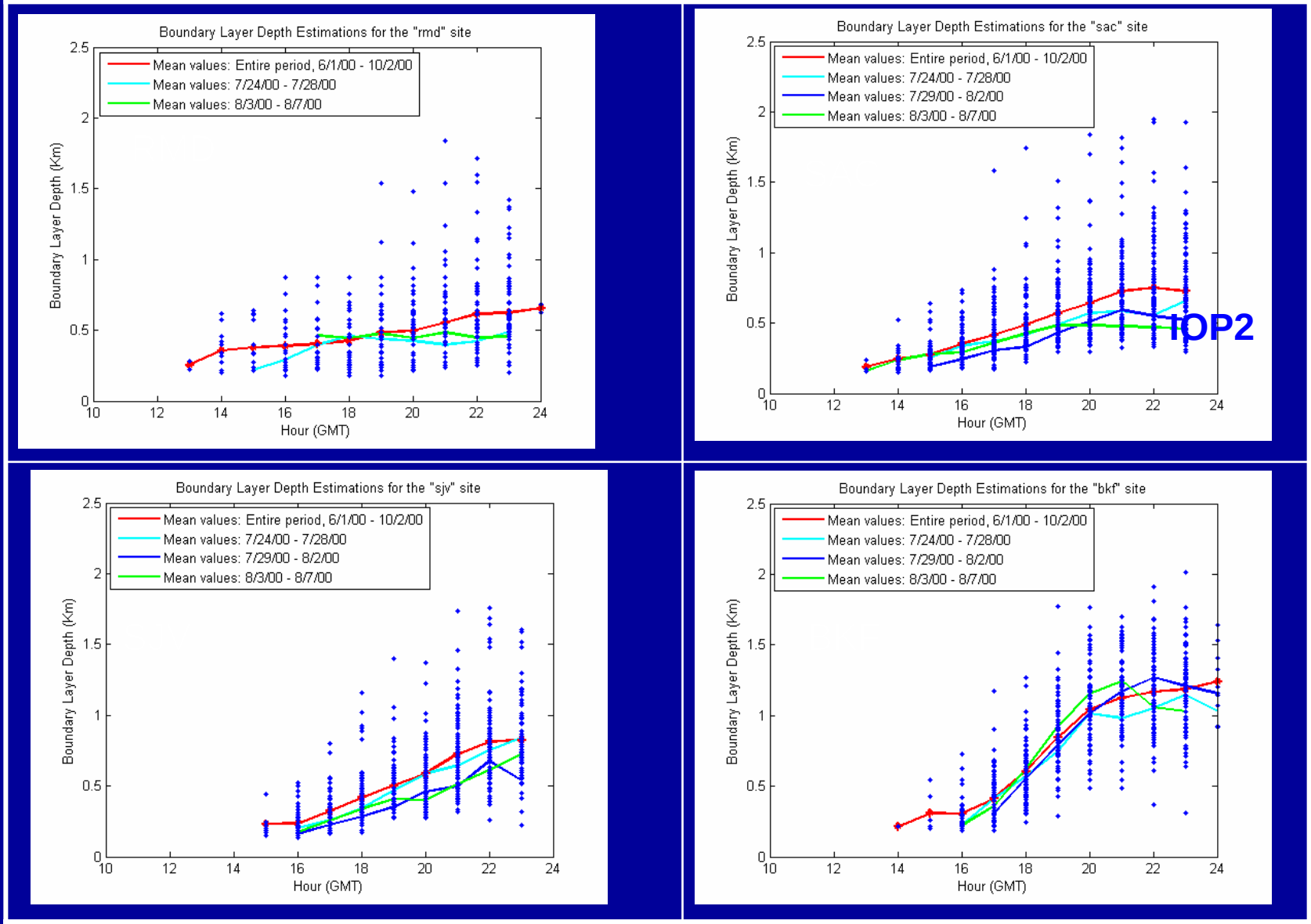


200 Meter Winds on July 31, 2000 at 10 PST

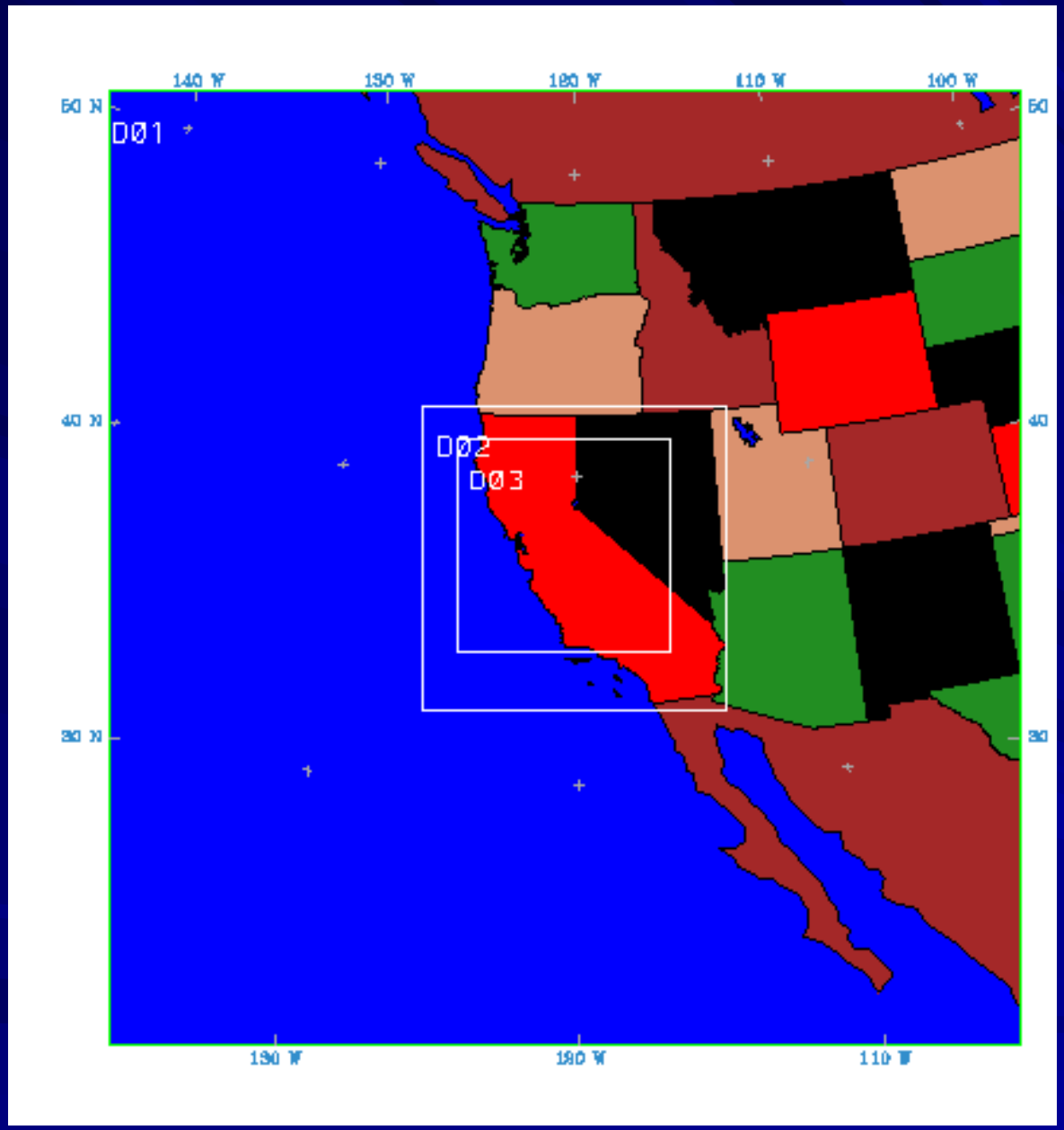

rc SNR (dB)
30 35 40 45 50 55 60 65 70 75 80
Height AGL (km)
-5 -4 -3 -2 -1 0 1 2 3 4 5
Height AGL (km)
0 0.5 1 1.5 2 2.5 3 3.5 4
Height AGL (km)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Site: bkf
Year: 00
Day: 200
UTC (h)
Beam index: 2



PBL depth climatology – summer 2000



PBL depth climatology



36km grid 95x91

12km grid 91x91

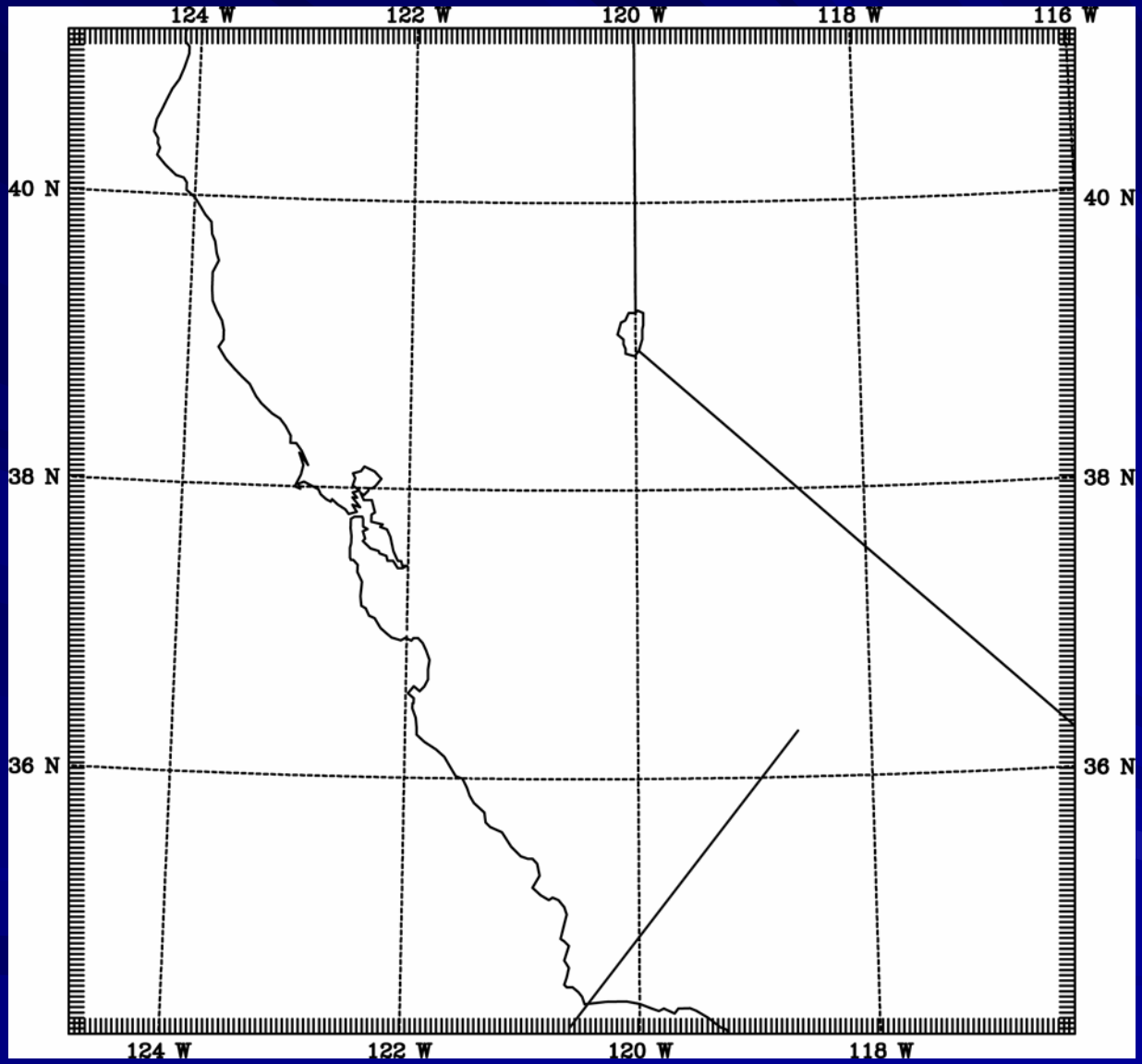
4km grid 190x190

All have 50 layers, with 22 in lowest 1km and lowest model level at 12m

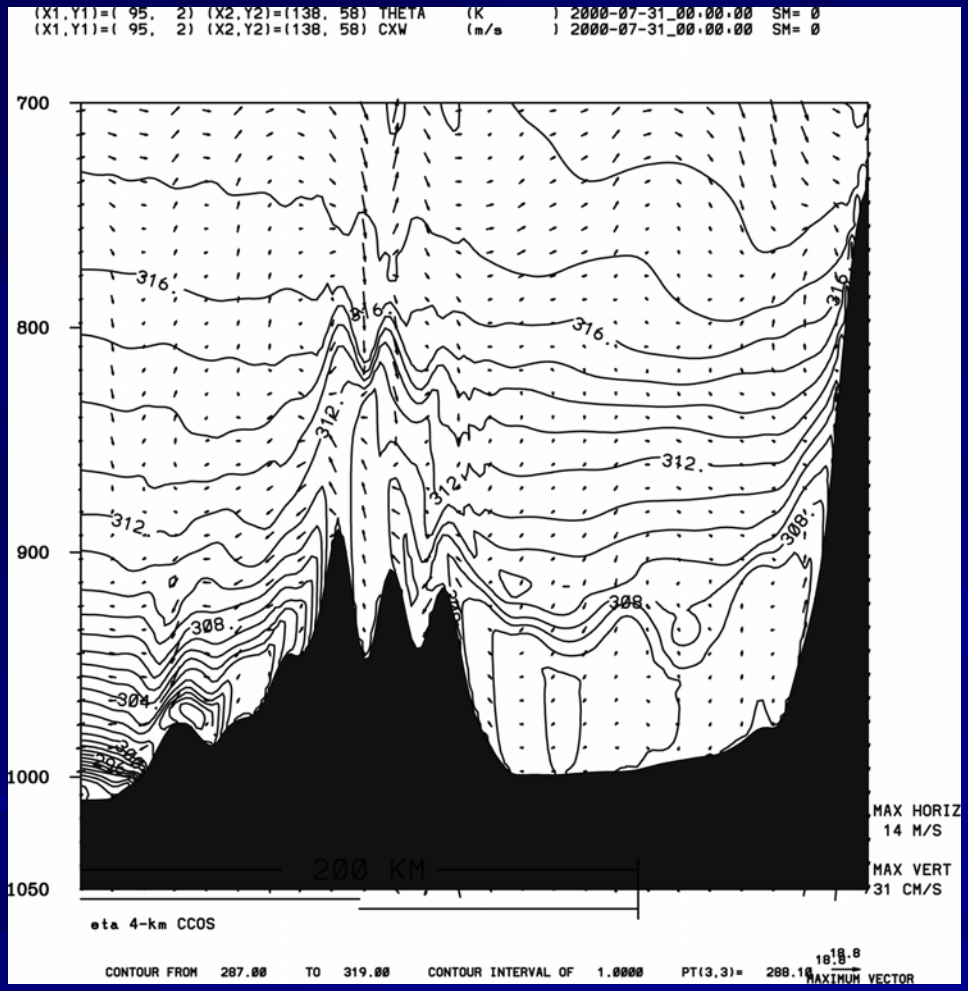
One-way nesting

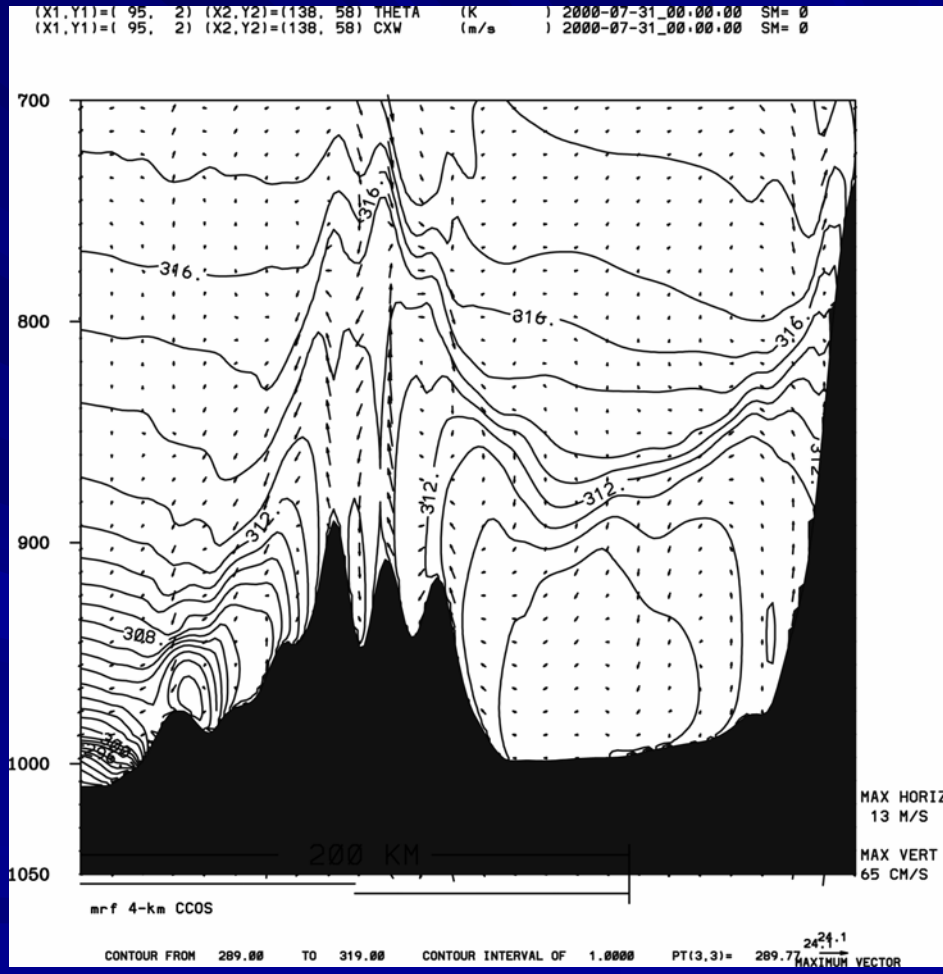
Model Simulation Specifications

- Initial and boundary conditions
  - Eta 40km, 6 hourly
- Land Surface Schemes
  - 5-layer soil model
  - NOAH LSM
- Radiation
  - Dudhia SW radiation
  - RRTM LW radiation
- Microphysics
  - Grell conv on 36 and 12km grids
  - Reisner 1 explicit microphysics (all grids)
- PBL
  - MRF
  - Eta
- FDDA
  - Analysis nudging of v, T, q on 36km grid, above PBL only
  - Obs nudging of profiler and surface winds on 4km grid


124 W
122 W
120 W
118 W
116 W
40 N
38 N
36 N
124 W
122 W
120 W
118 W

Theta cross-section

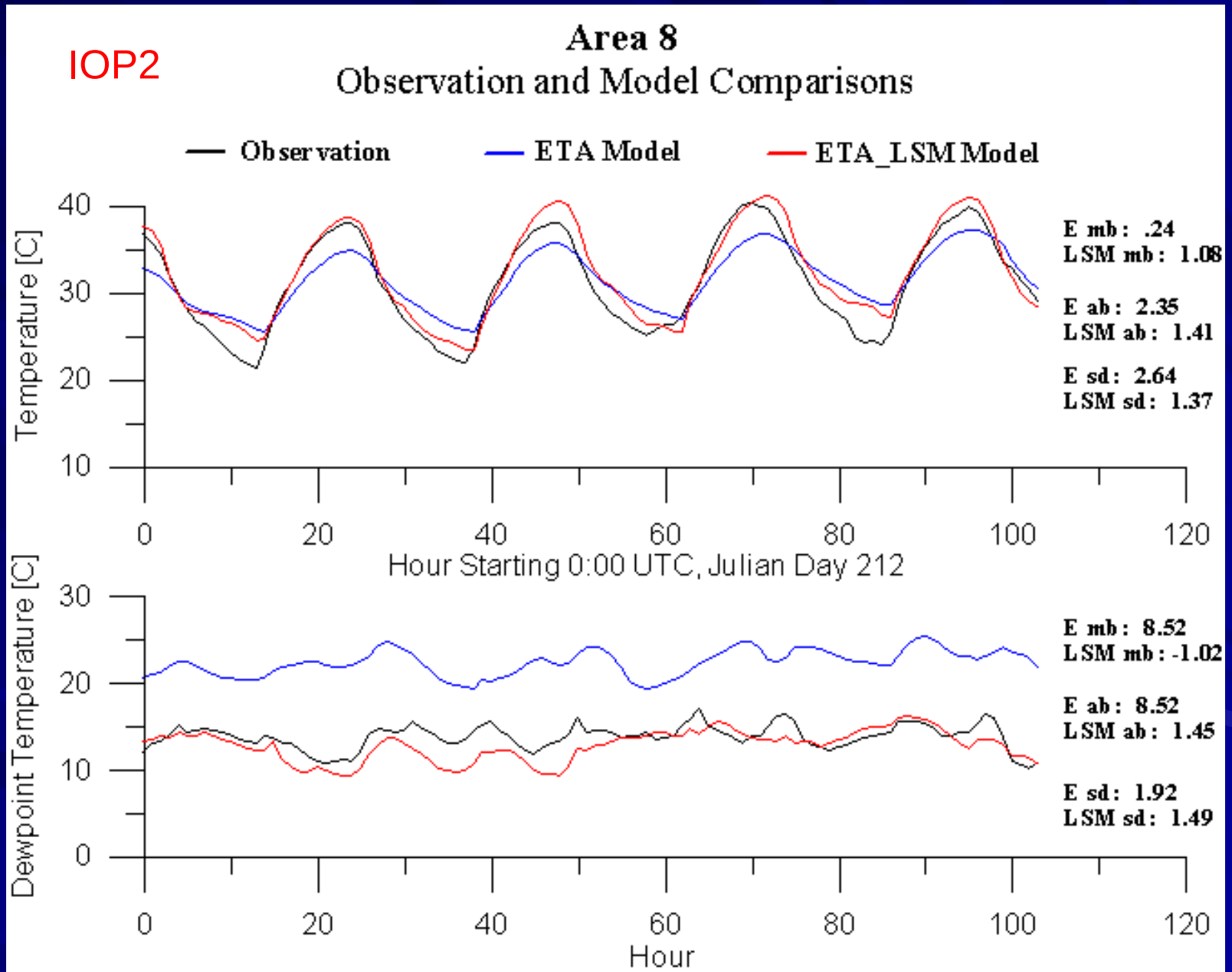




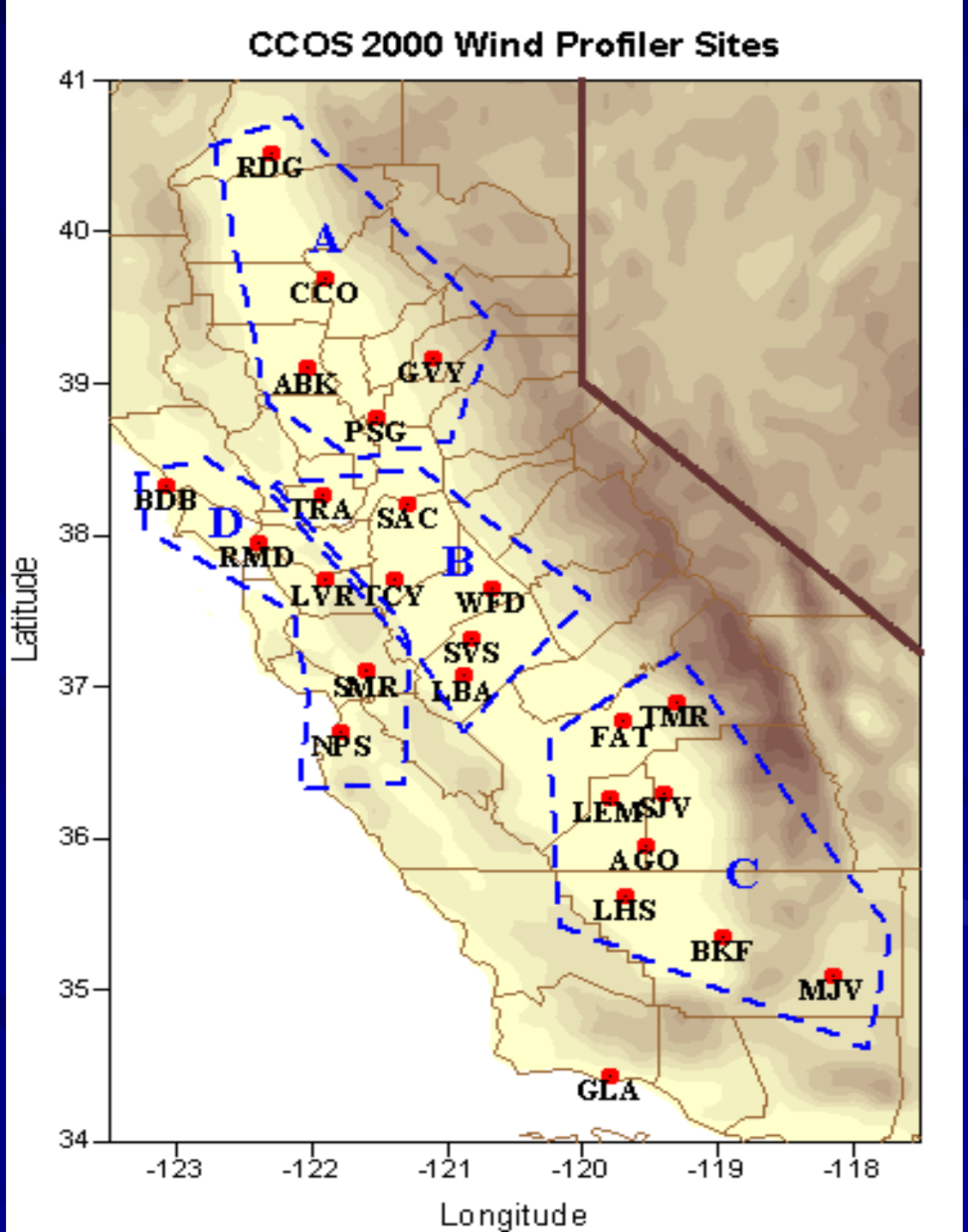
Eta PBL / 5-layer soil

MRF PBL / 5-layer soil

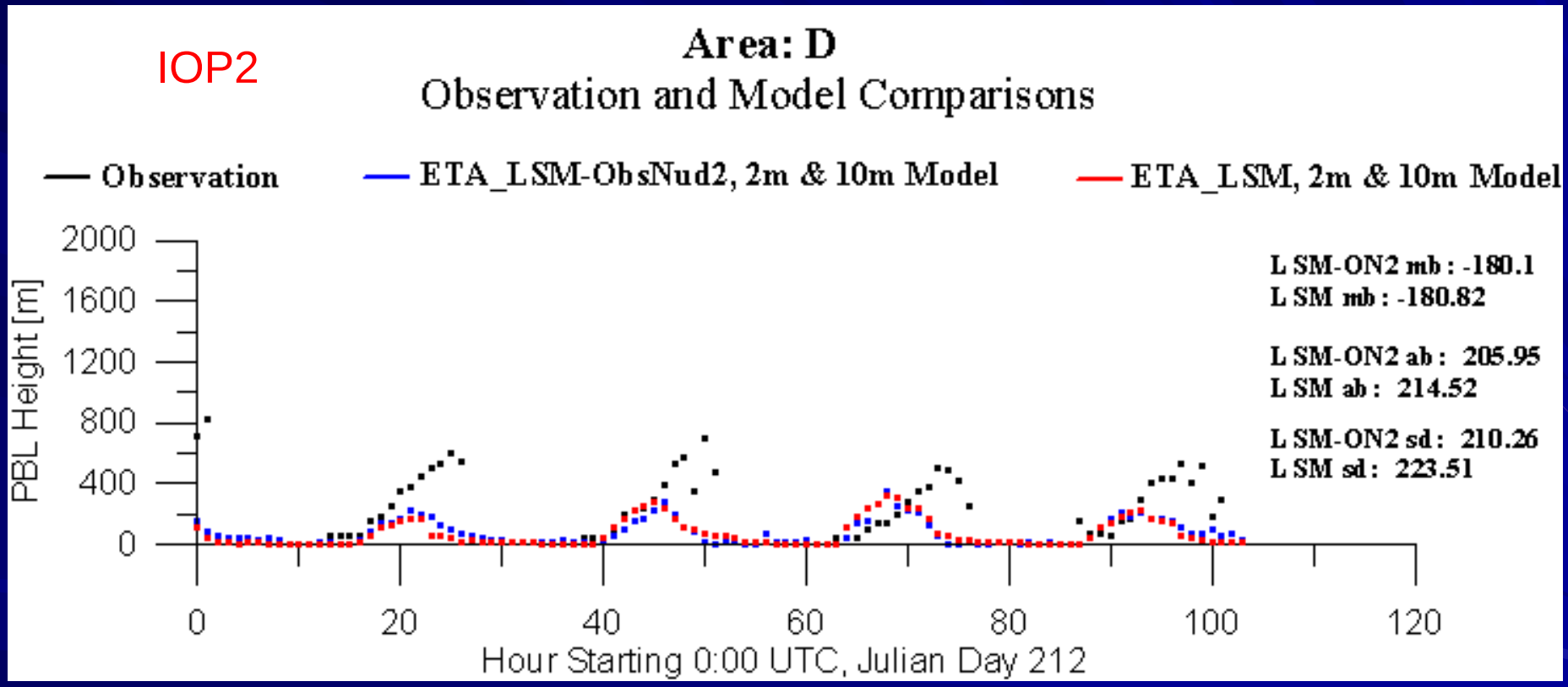
5-layer soil model vs. NOAH LSM



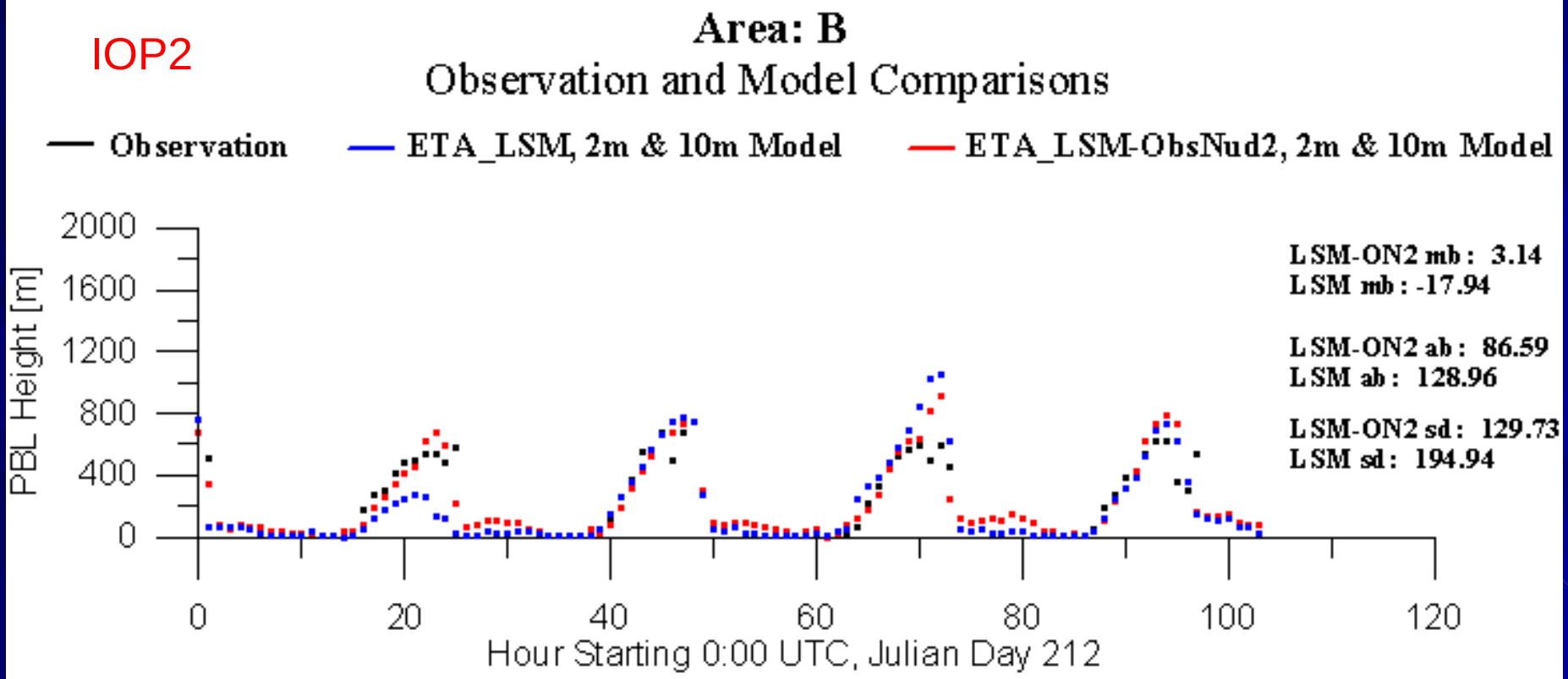
Average
PBL depths



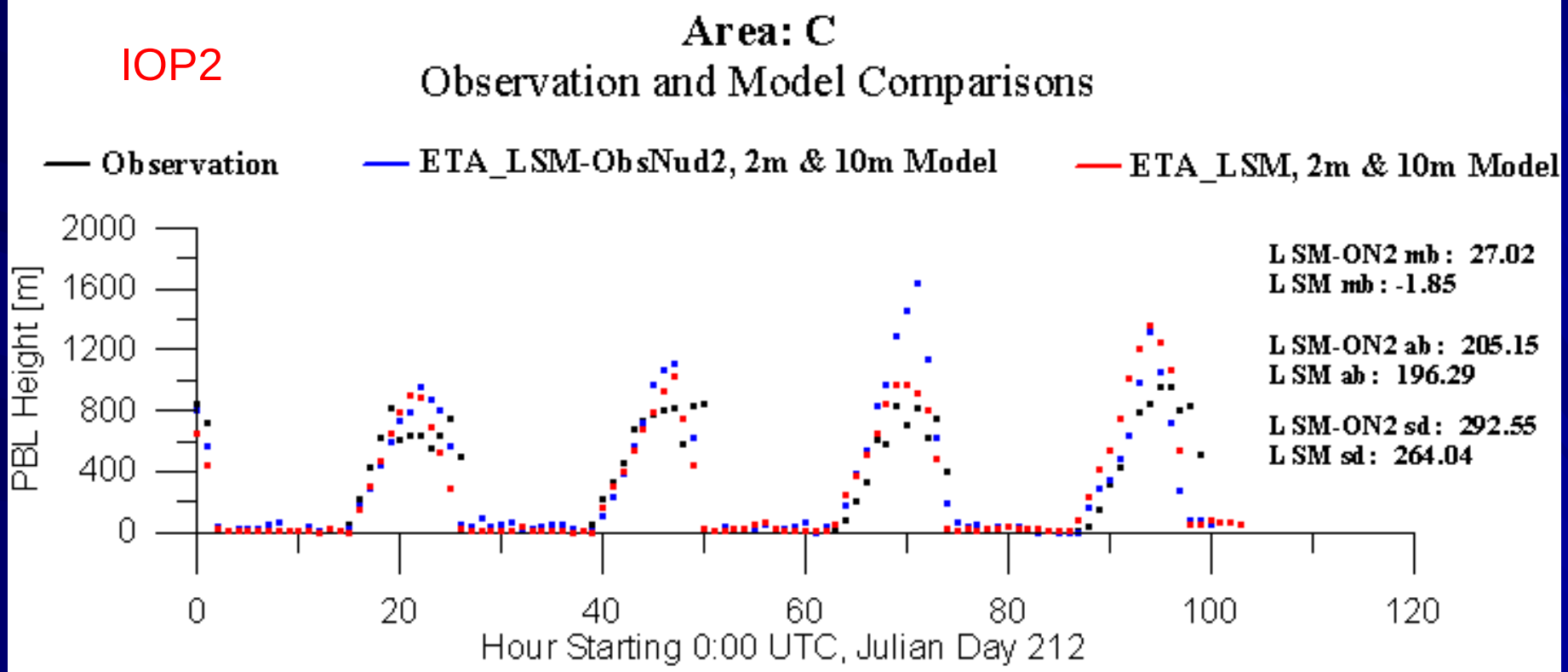
IOP2

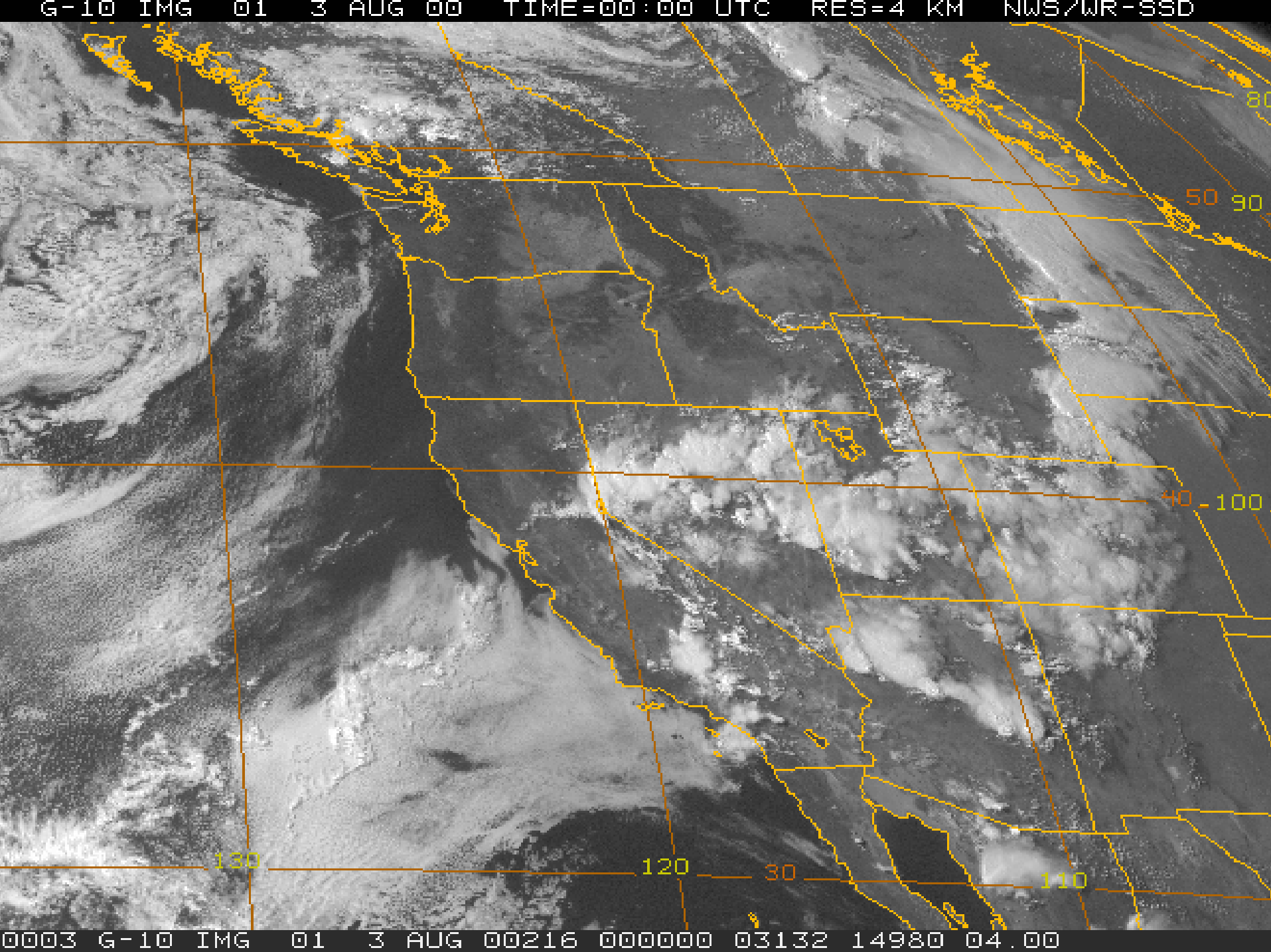

Area: D
Observation and Model Comparisons
Observation
ETA_LSM-ObsNud2, 2m & 10m Model
ETA_LSM, 2m & 10m Model
PBL Height [m]
2000
1600
1200
800
400
0
0
20
40
60
80
100
120
Hour Starting 0:00 UTC, Julian Day 212
LSM-ON2 mb : -180.1
LSM mb : -180.82
LSM-ON2 ab : 205.95
LSM ab : 214.52
LSM-ON2 sd : 210.26
LSM sd : 223.51

IOP2

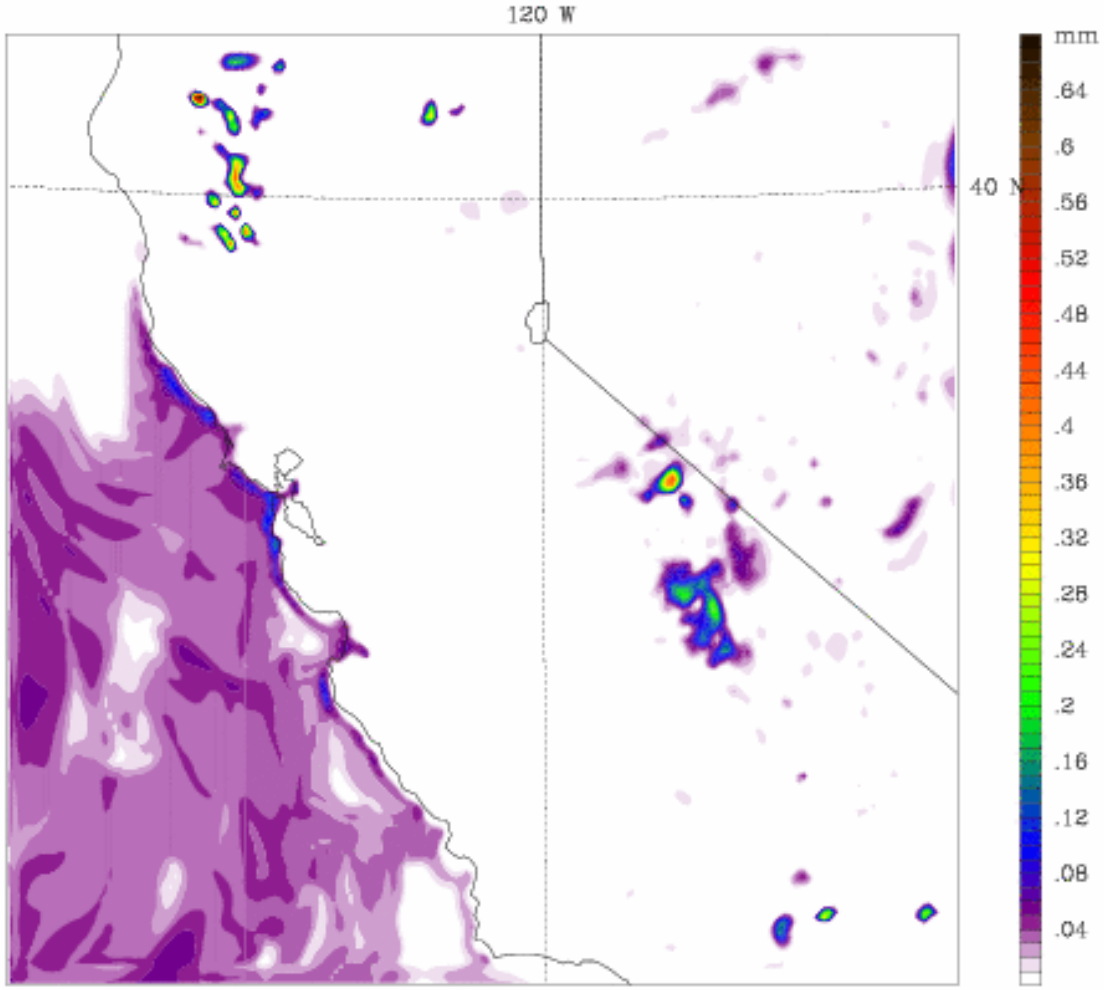

Area: B
Observation and Model Comparisons
Observation
ETA_LSM, 2m & 10m Model
ETA_LSM-ObsNud2, 2m & 10m Model
PBL Height [m]
2000
1600
1200
800
400
0
0
20
40
60
80
100
120
Hour Starting 0:00 UTC, Julian Day 212
LSM-ON2 mb : 3.14
LSM mb : -17.94
LSM-ON2 ab : 86.59
LSM ab : 128.96
LSM-ON2 sd : 129.73
LSM sd : 194.94

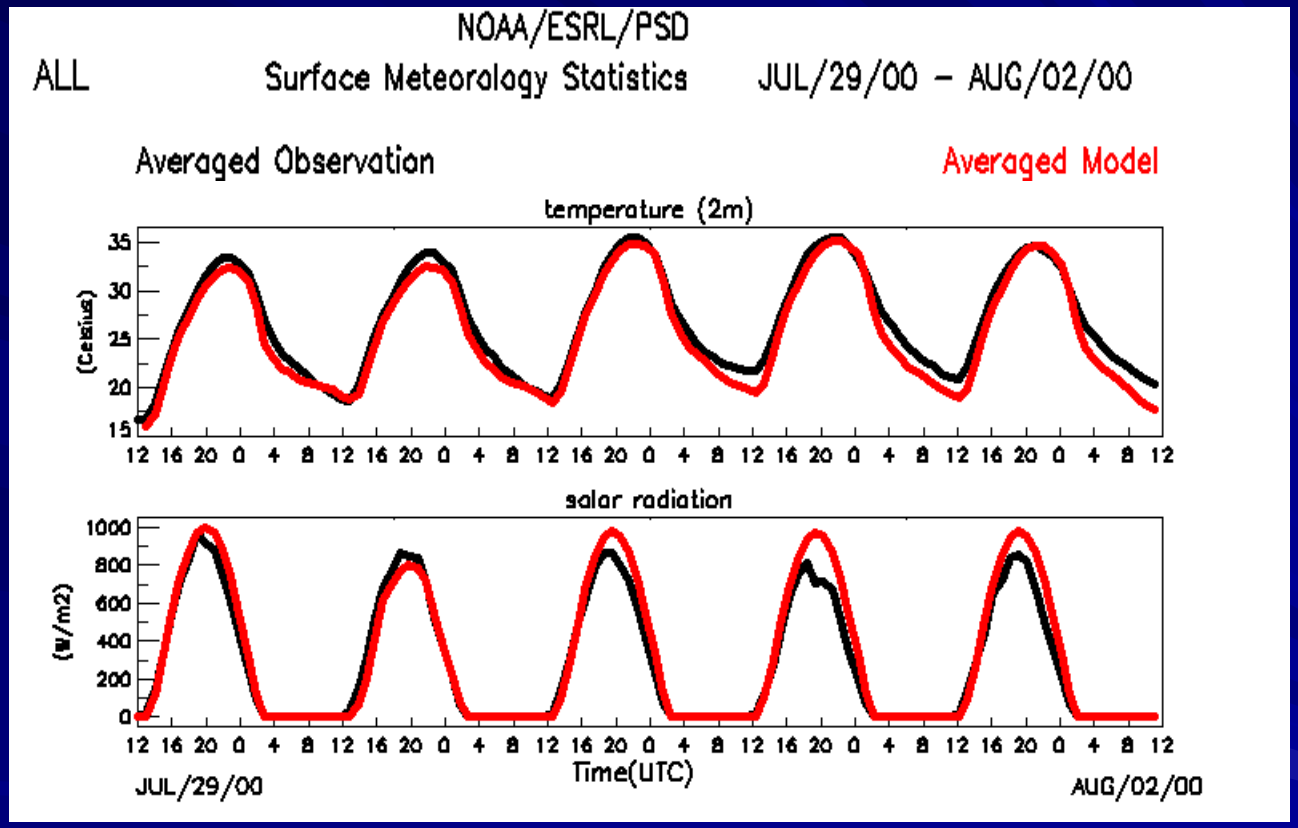
IOP2


Area: C
Observation and Model Comparisons
Observation
ETA_LSM-ObsNud2, 2m & 10m Model
ETA_LSM, 2m & 10m Model
PBL Height [m]
2000
1600
1200
800
400
0
0
20
40
60
80
100
120
Hour Starting 0:00 UTC, Julian Day 212
LSM-ON2 mb : 27.02
LSM mb : -1.85
LSM-ON2 ab : 205.15
LSM ab : 196.29
LSM-ON2 sd : 292.55
LSM sd : 264.04


G-10 IMG 01 3 AUG 00 TIME=00:00 UTC RES=4 KM NWS/WR-SSD
80
50
90
40
100
130
120
30
110
0003 G-10 IMG 01 3 AUG 00216 000000 03132 14980 04.00

Dataset: mm5v3.6 4km eta RIP: rip.ccos.4kmmm5v Init: 1200 UTC Sat 29 Jul 00
Fcst: 108.00 Valid: 0000 UTC Thu 03 Aug 00 (1800 MDT Wed 02 Aug 00)
Column-integ. cloud hydrometeors



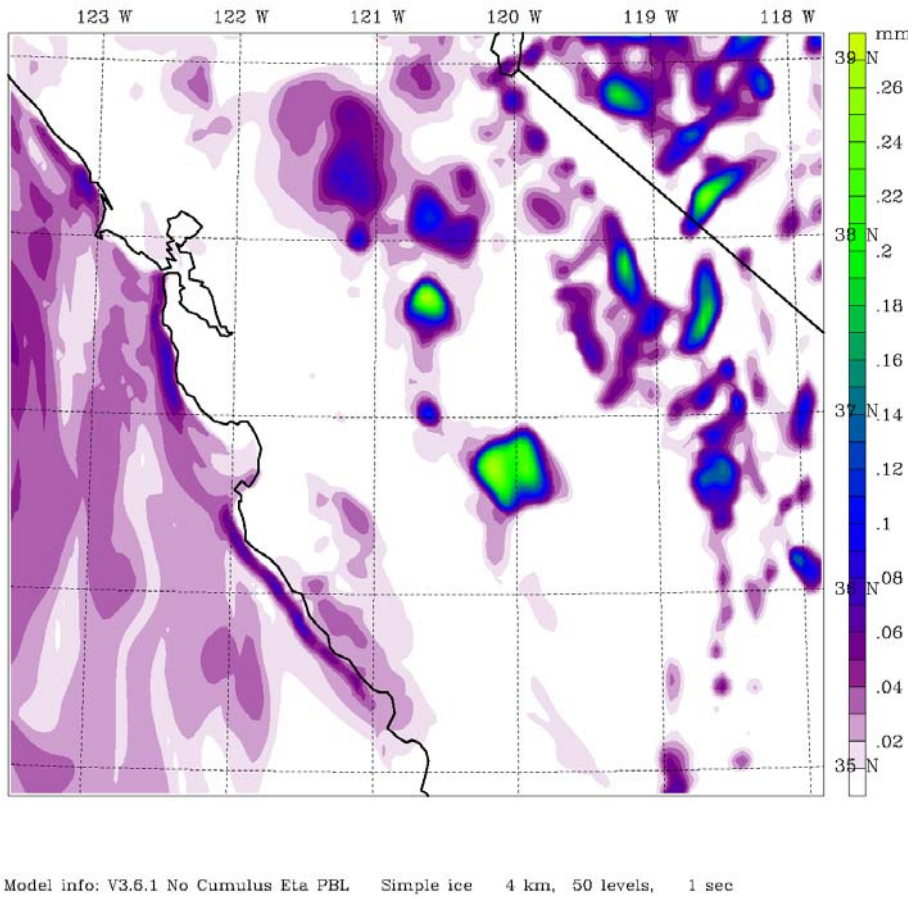


2m Temp and solar radiation averaged over 14 NOAA wind profiler sites

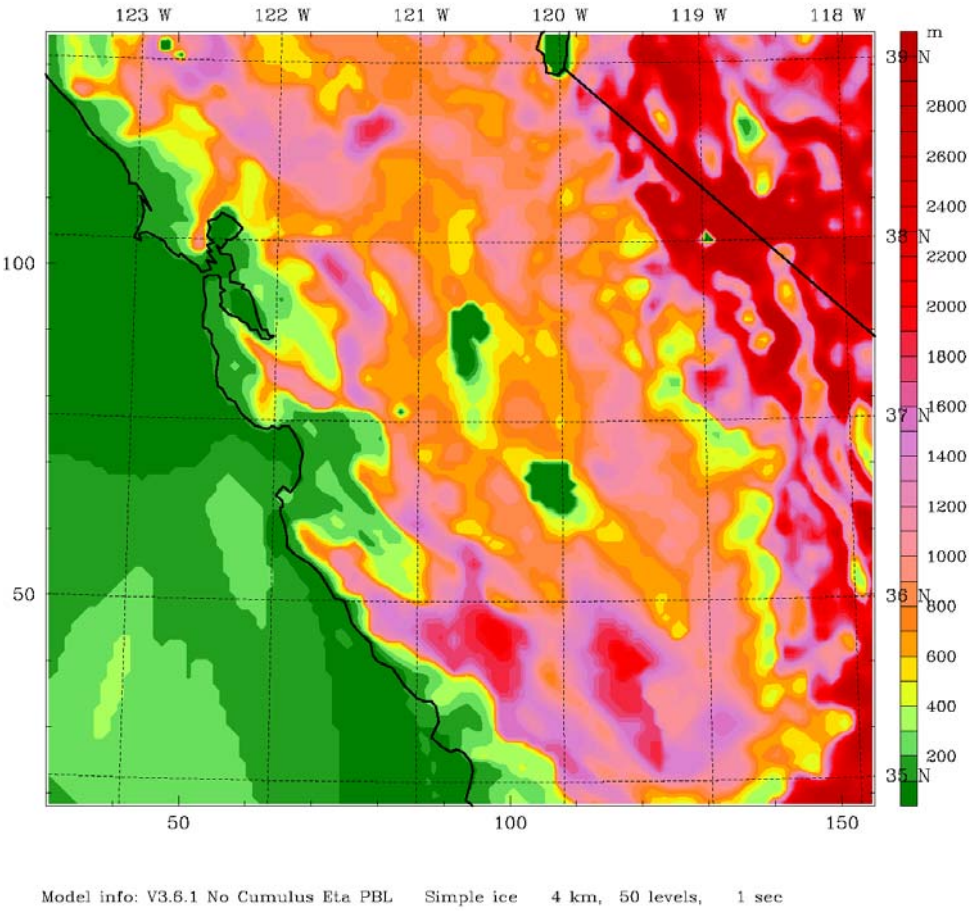
Effect of clouds on PBL Depth

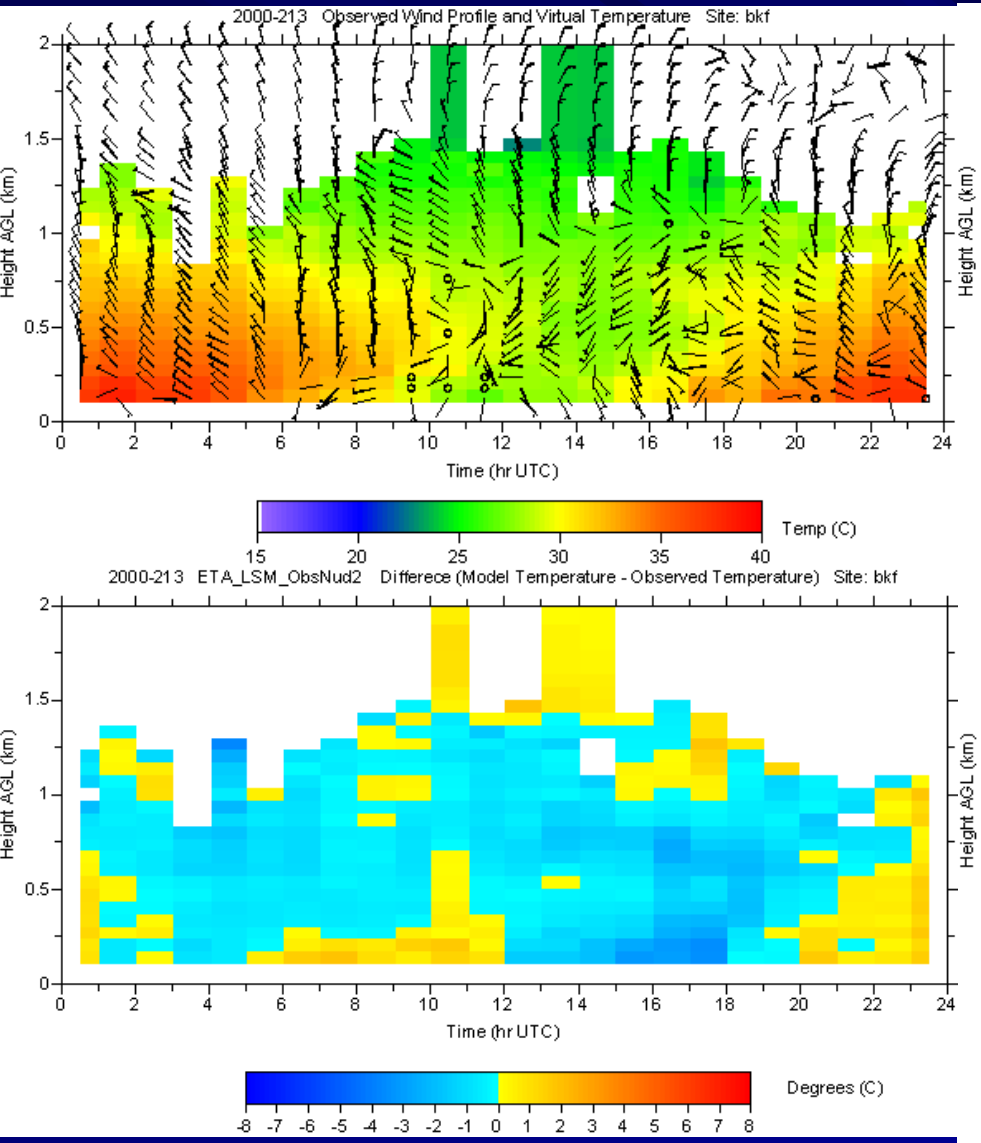
1800 PDT 30 July 2000

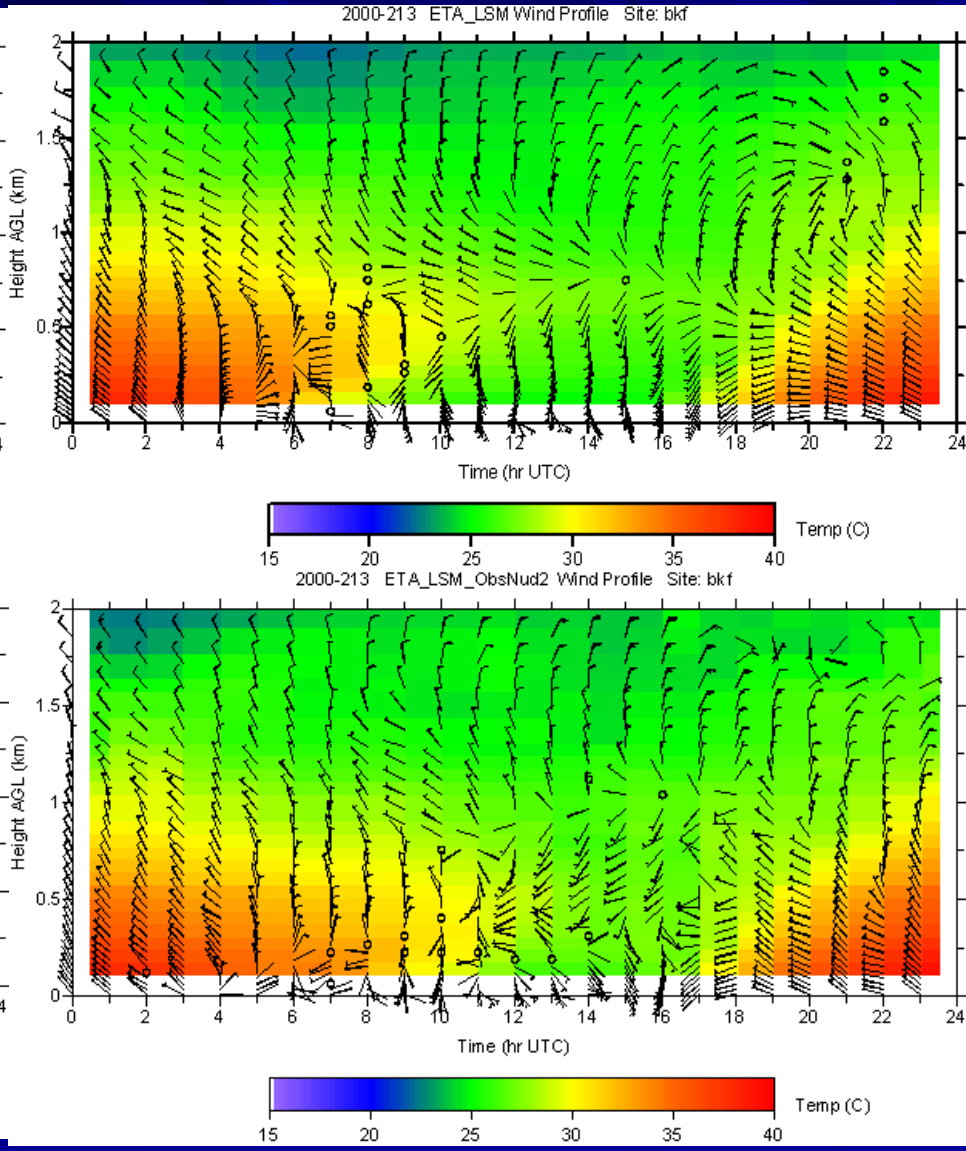
Integrated cloud hydrometeors



PBL Depth Thetav Method



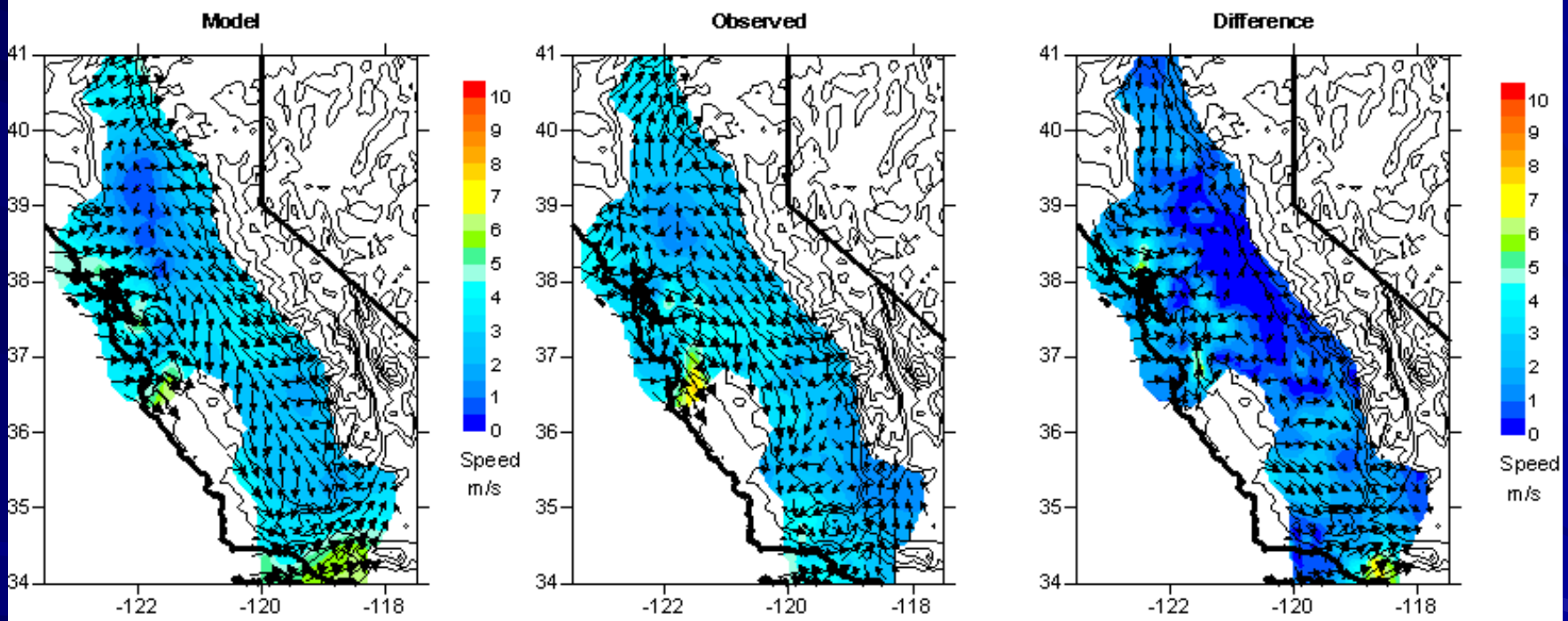




RASS Temperatures – Bakersfield JD213

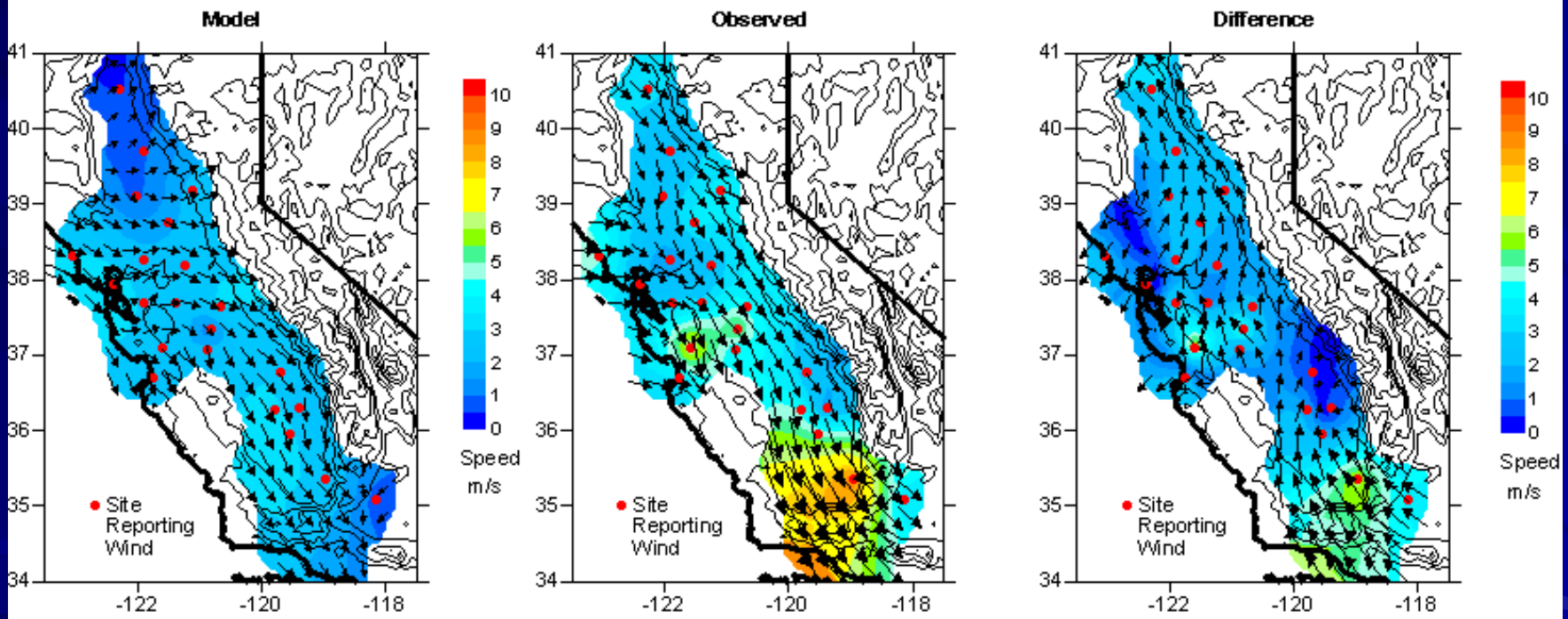
Winds

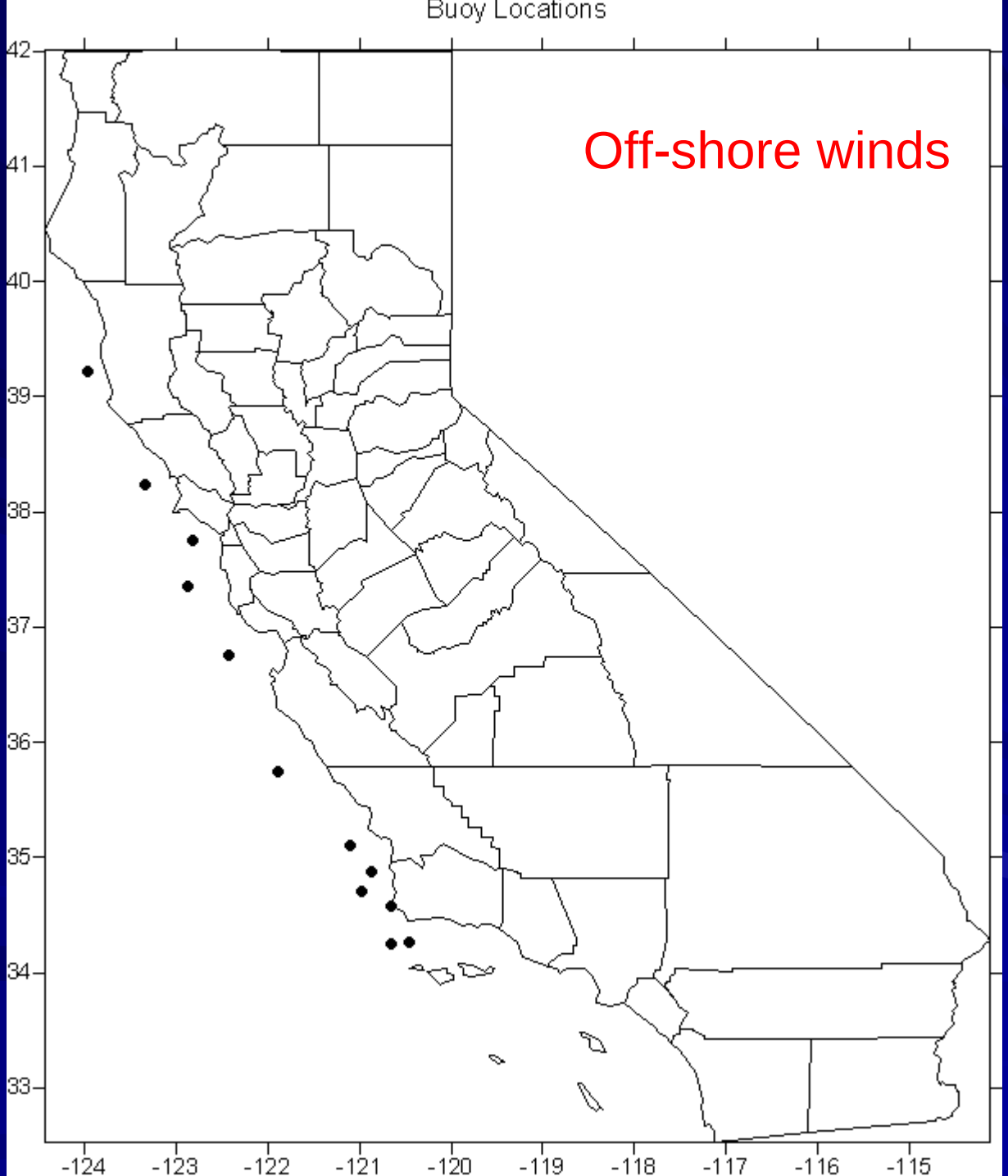
2000-213 22 UTC at Surface ETA_LSM, 2m & 10m

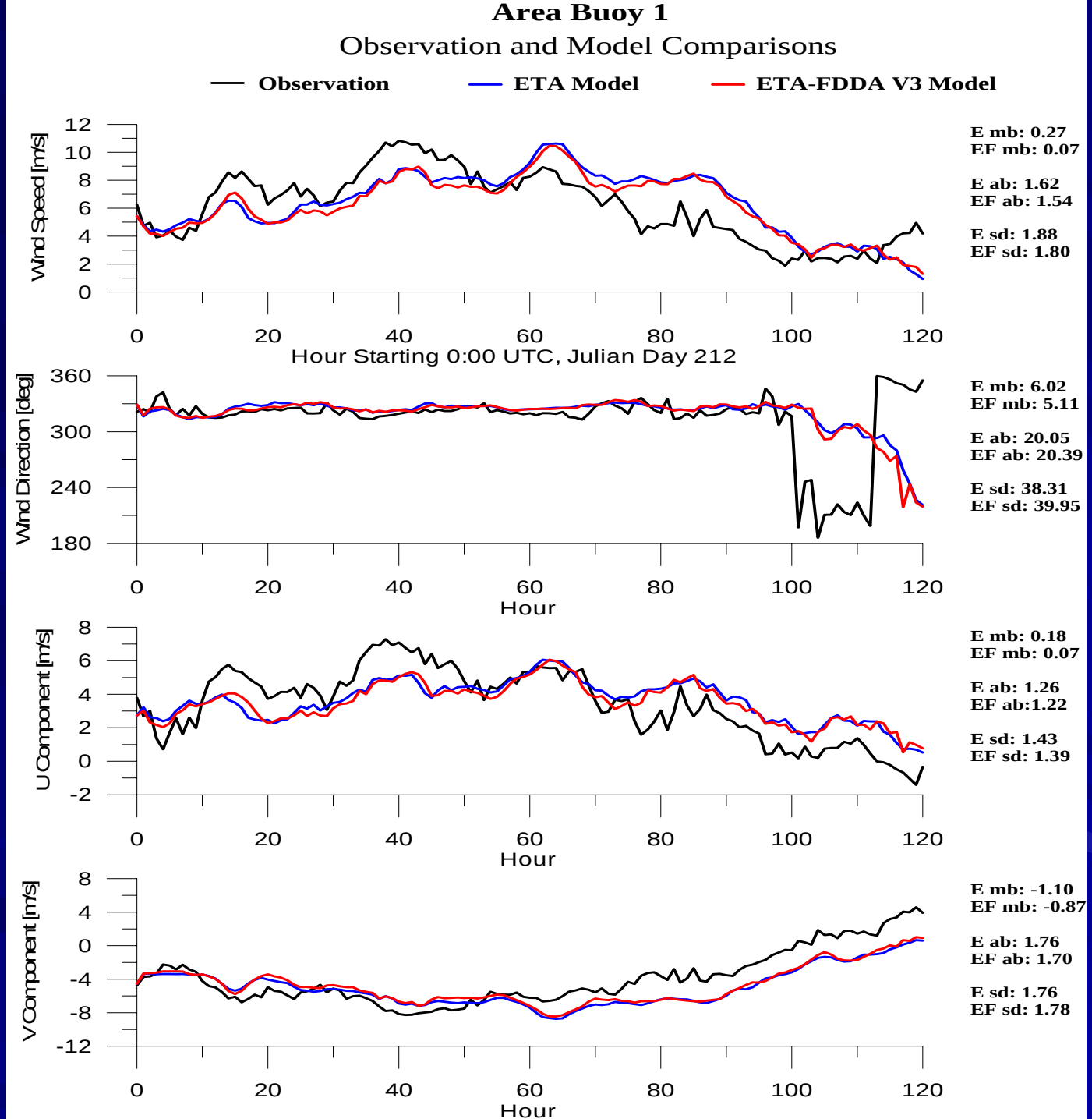


Winds

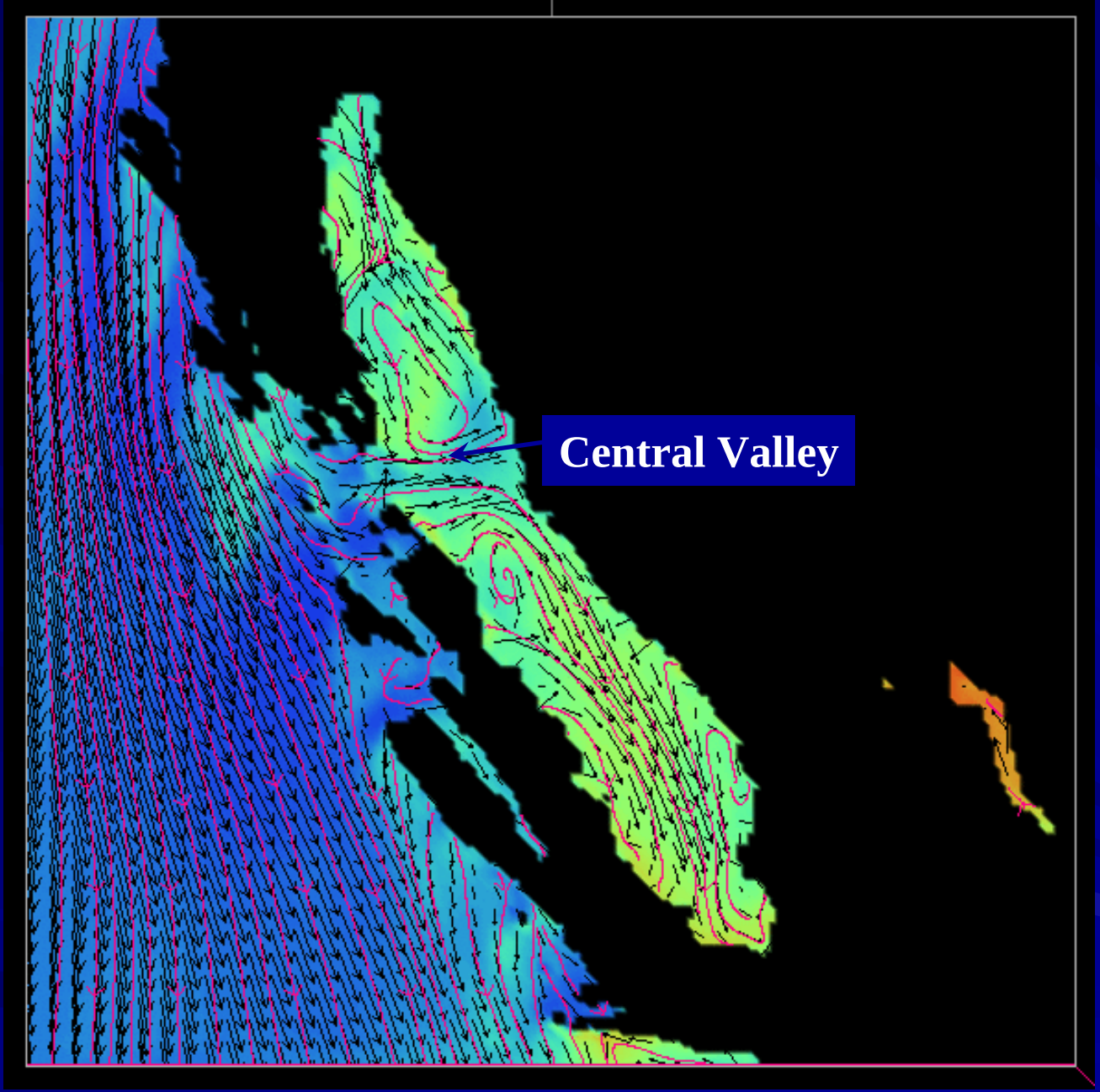
2000-213 22 UTC at 500 m AGL ETA_LSM




Buoy Locations
Off-shore winds
42
41
40
39
38
37
36
35
34
33
-124
-123
-122
-121
-120
-119
-118
-117
-116
-115

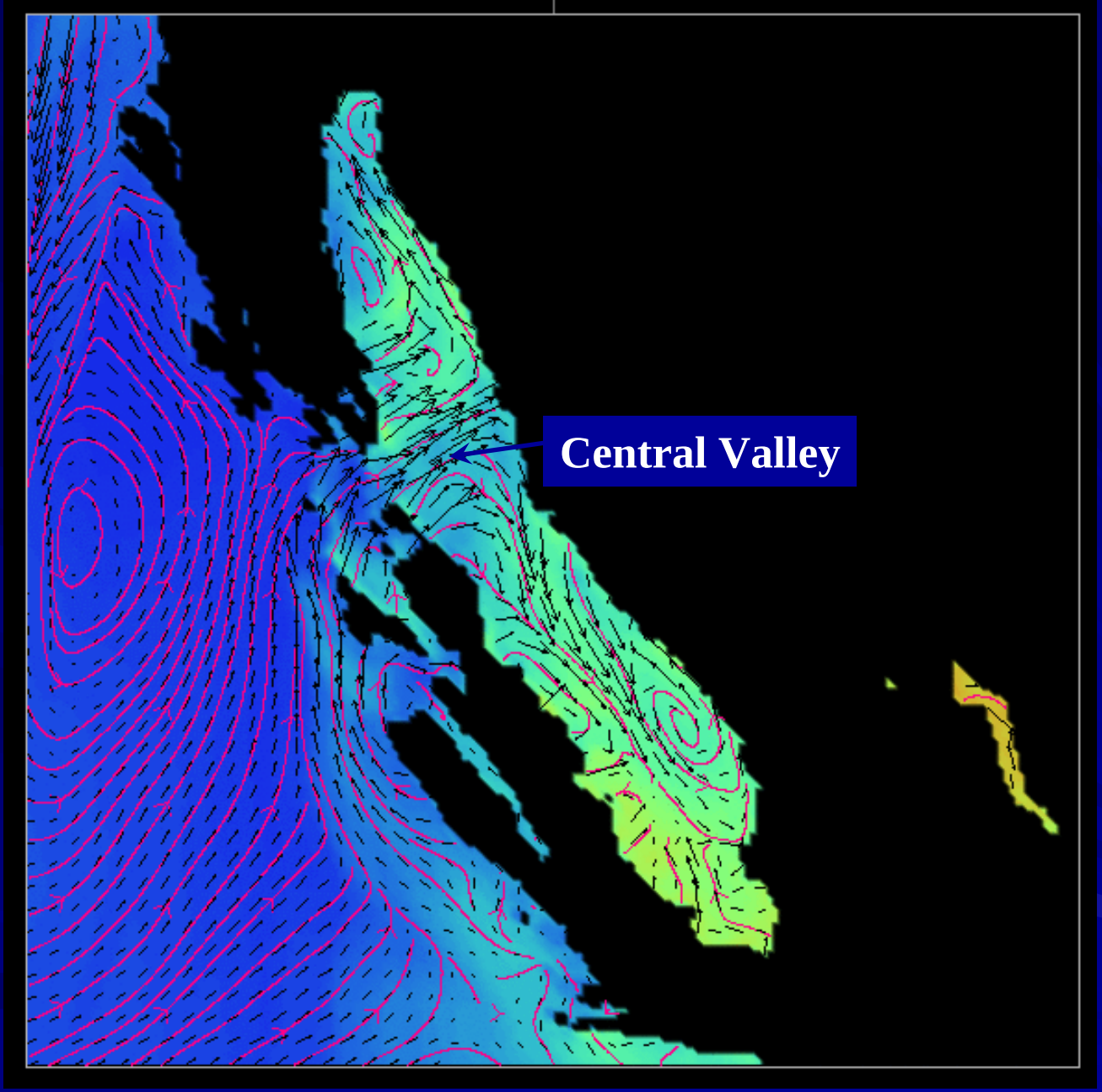

Area Buoy 1
Observation and Model Comparisons
Observation
ETA Model
ETA-FDDA V3 Model
Wind Speed [m/s]
E mb: 0.27
EF mb: 0.07
E ab: 1.62
EF ab: 1.54
E sd: 1.88
EF sd: 1.80
Hour Starting 0:00 UTC, Julian Day 212
Wind Direction [deg]
E mb: 6.02
EF mb: 5.11
E ab: 20.05
EF ab: 20.39
E sd: 38.31
EF sd: 39.95
Hour
U Component [m/s]
E mb: 0.18
EF mb: 0.07
E ab: 1.26
EF ab:1.22
E sd: 1.43
EF sd: 1.39
Hour
V Component [m/s]
E mb: -1.10
EF mb: -0.87
E ab: 1.76
EF ab: 1.70
E sd: 1.76
EF sd: 1.78
Hour

No FDDA
300m MSL



1000 UTC July 25, 2000

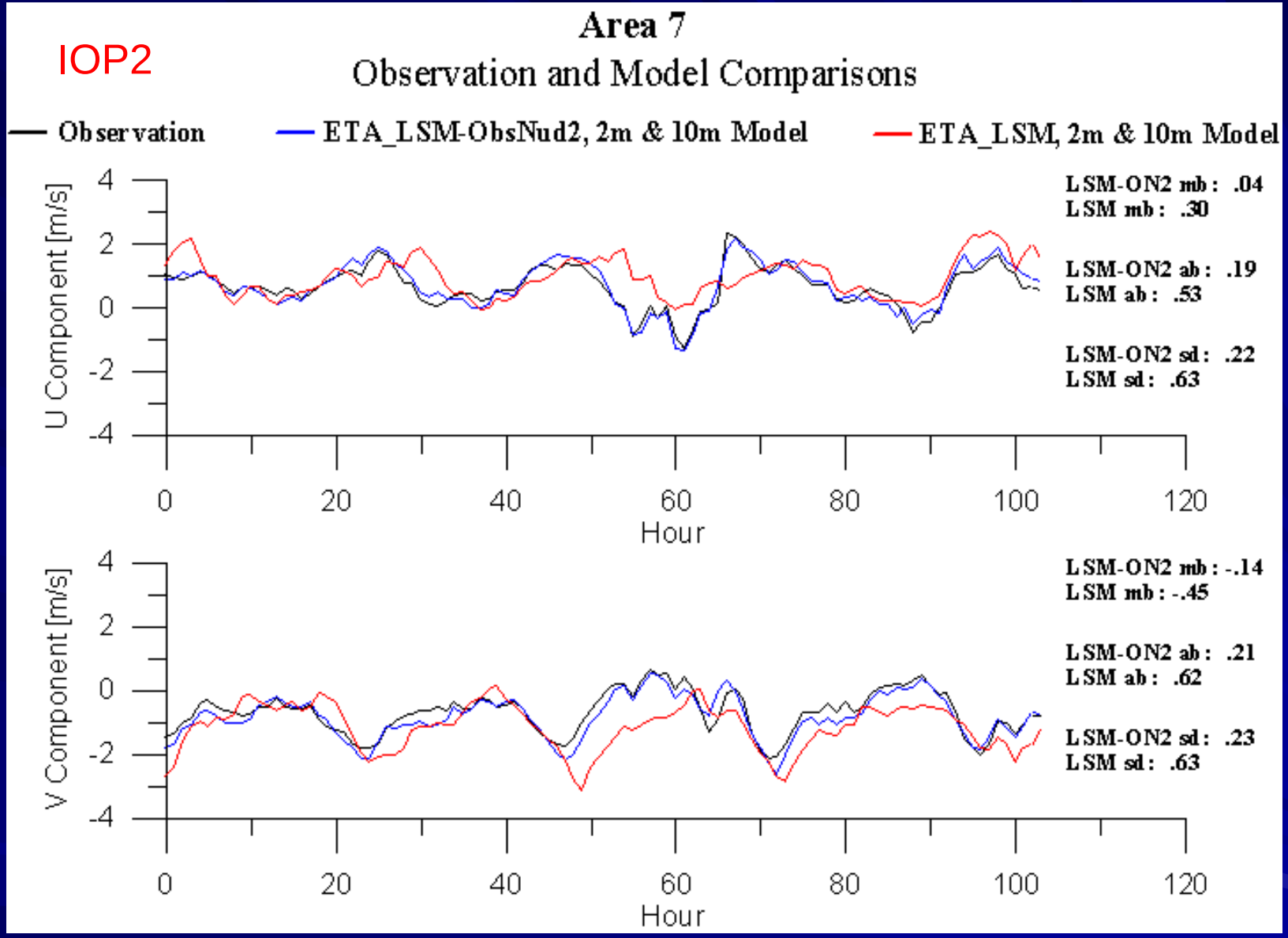
No FDDA
300m MSL



1100 UTC Aug 4, 2000

FDDA

- Profiler and surface (10m) winds only
- Observations are interpolated so that every model level up to maximum profiler height is nudged to an observed value
- 40 km radius of influence
- Trapezoidal time ramping function (20-40-20 min)

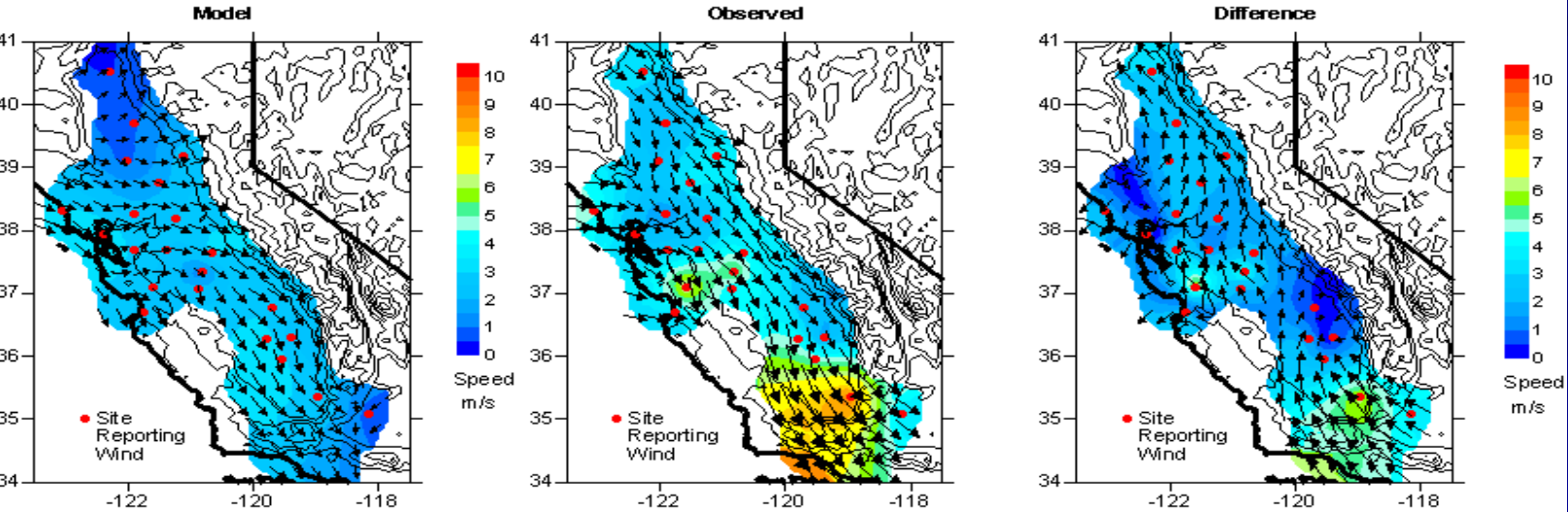


- Use of FDDA gives excellent agreement with surface winds

Winds

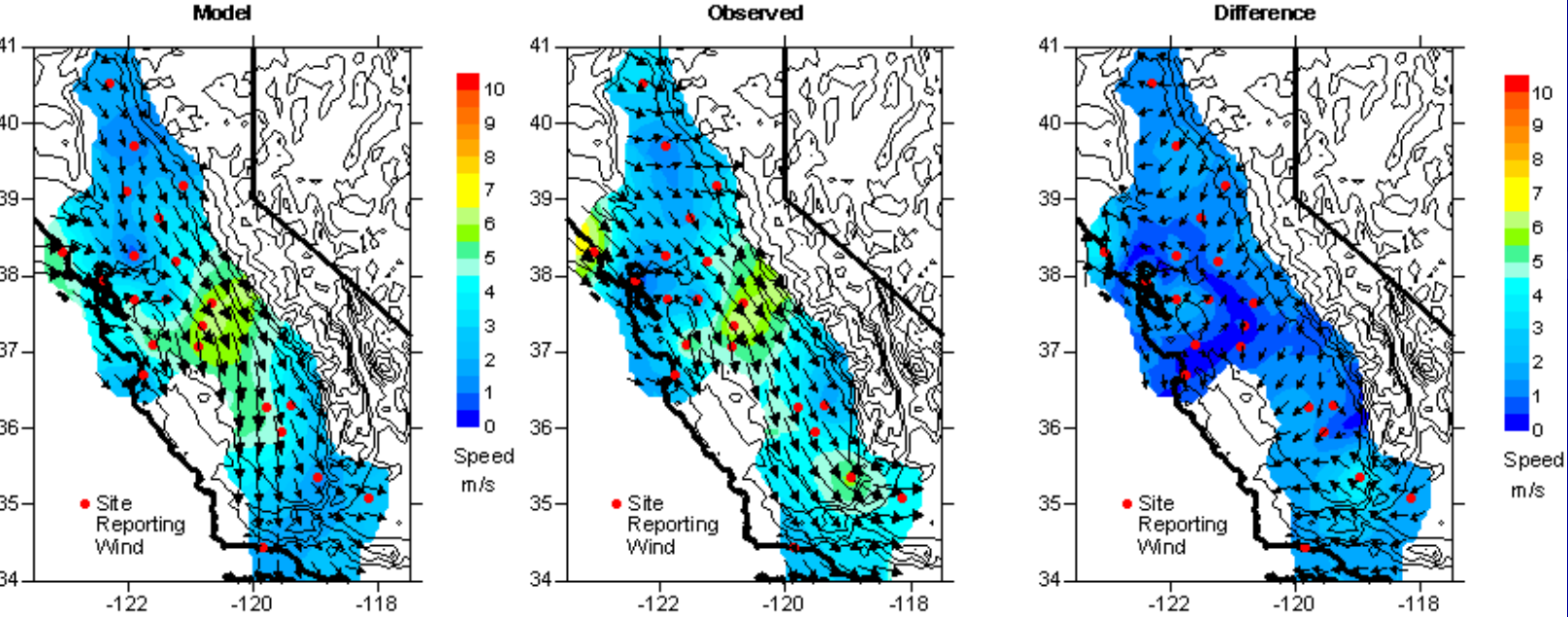
2000-213 22 UTC at 500 m AGL ETA_LSM

No FDDA

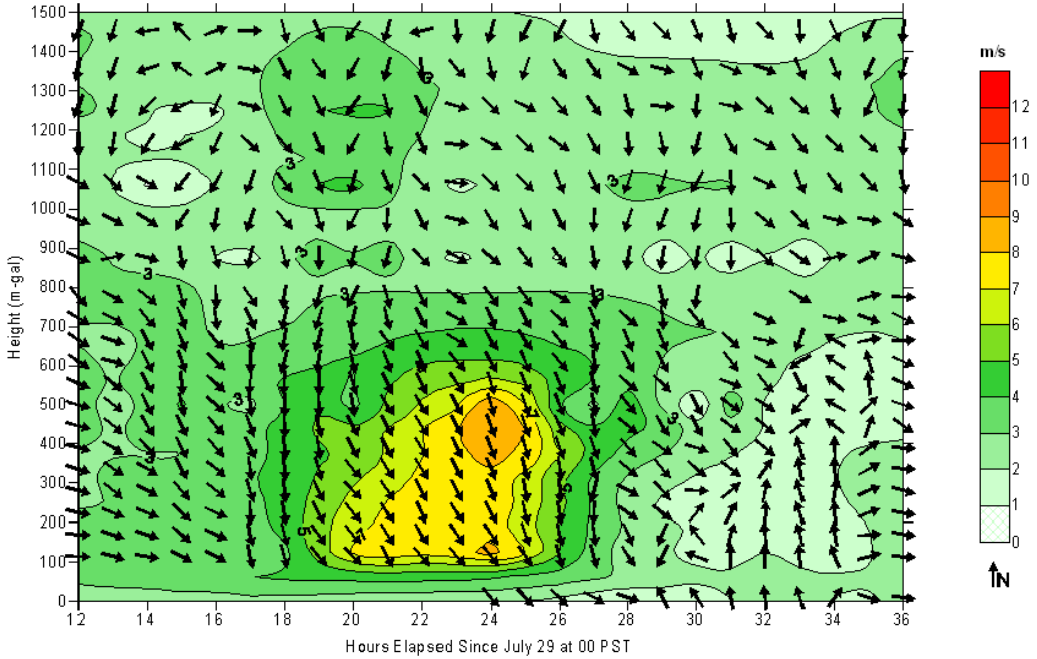


2000-213 22 UTC at 300 m AGL ETA_LSM-ObsNud2

FDDA

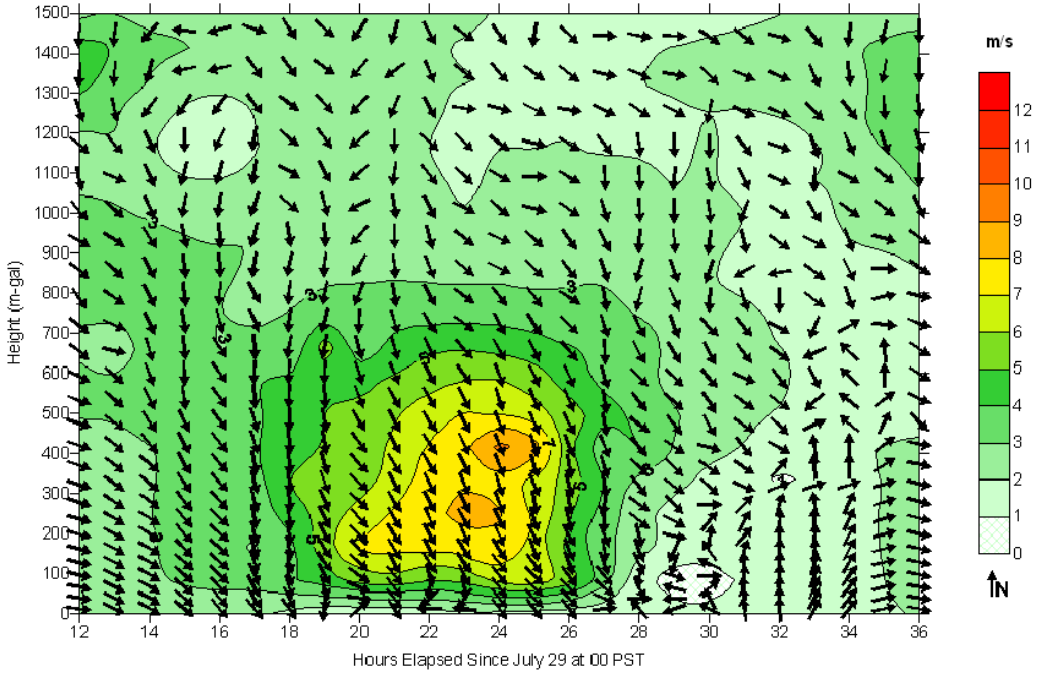


Obs



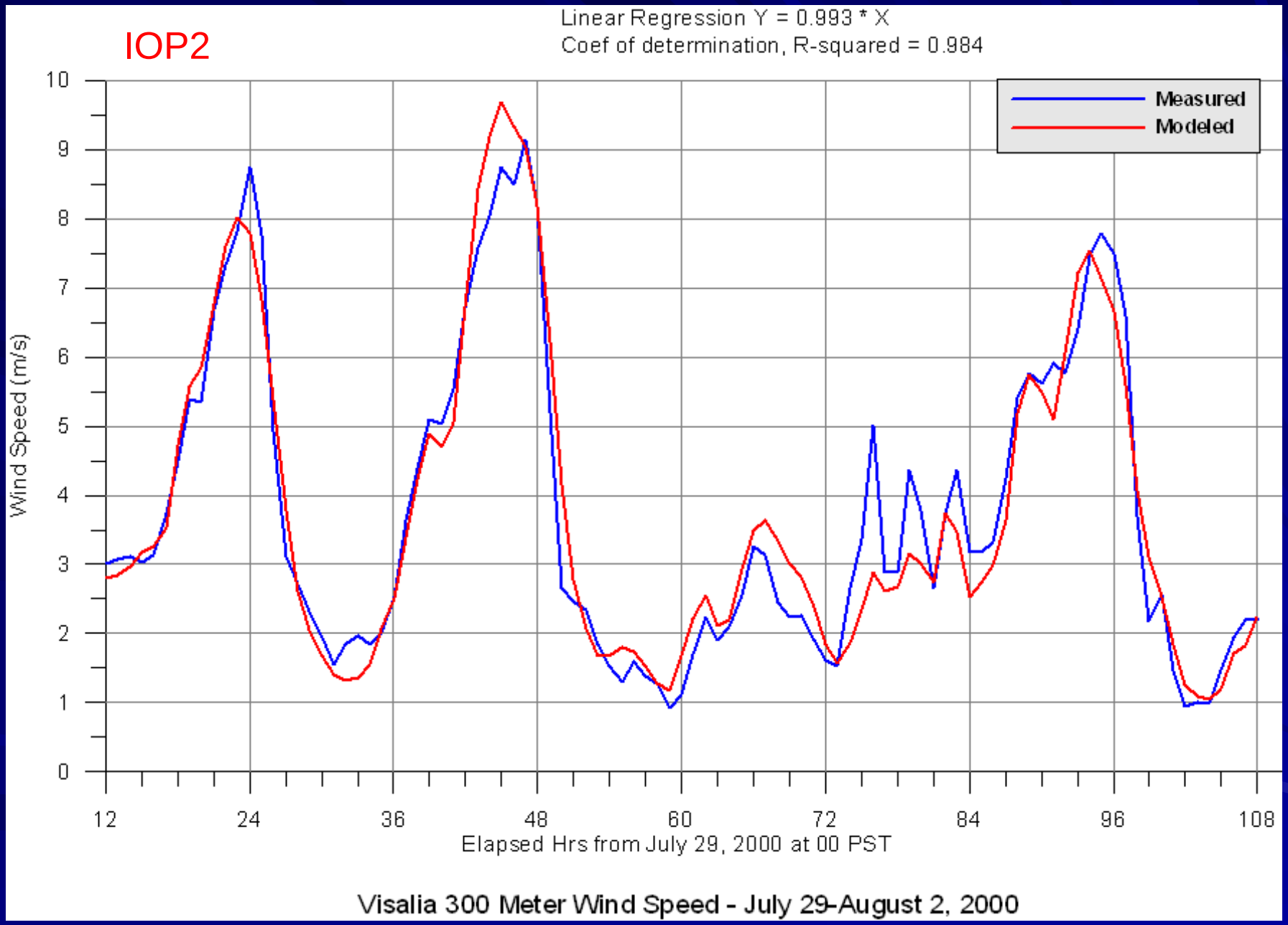
Measured Winds at Visalia - July 29 at 12 PST to July 30 at 12 PST

FDDA



MM5 Winds at Visalia - July 29 at 12 PST to July 30 at 12 PST

Courtesy Don Lehrman



Courtesy Don Lehrman

IOP2 regional surface wind speed biases (m/s)

AREA	No FDDA	FDDA
2	0.36	0.22
3	-0.01	-0.02
4	0.31	0.14
5	0.30	0.09
6	-0.01	-0.06
7	-0.02	0.05
8	0.12	0.01
9	-0.14	-0.16
Average	**0.11 m/s**	**0.03 m/s**

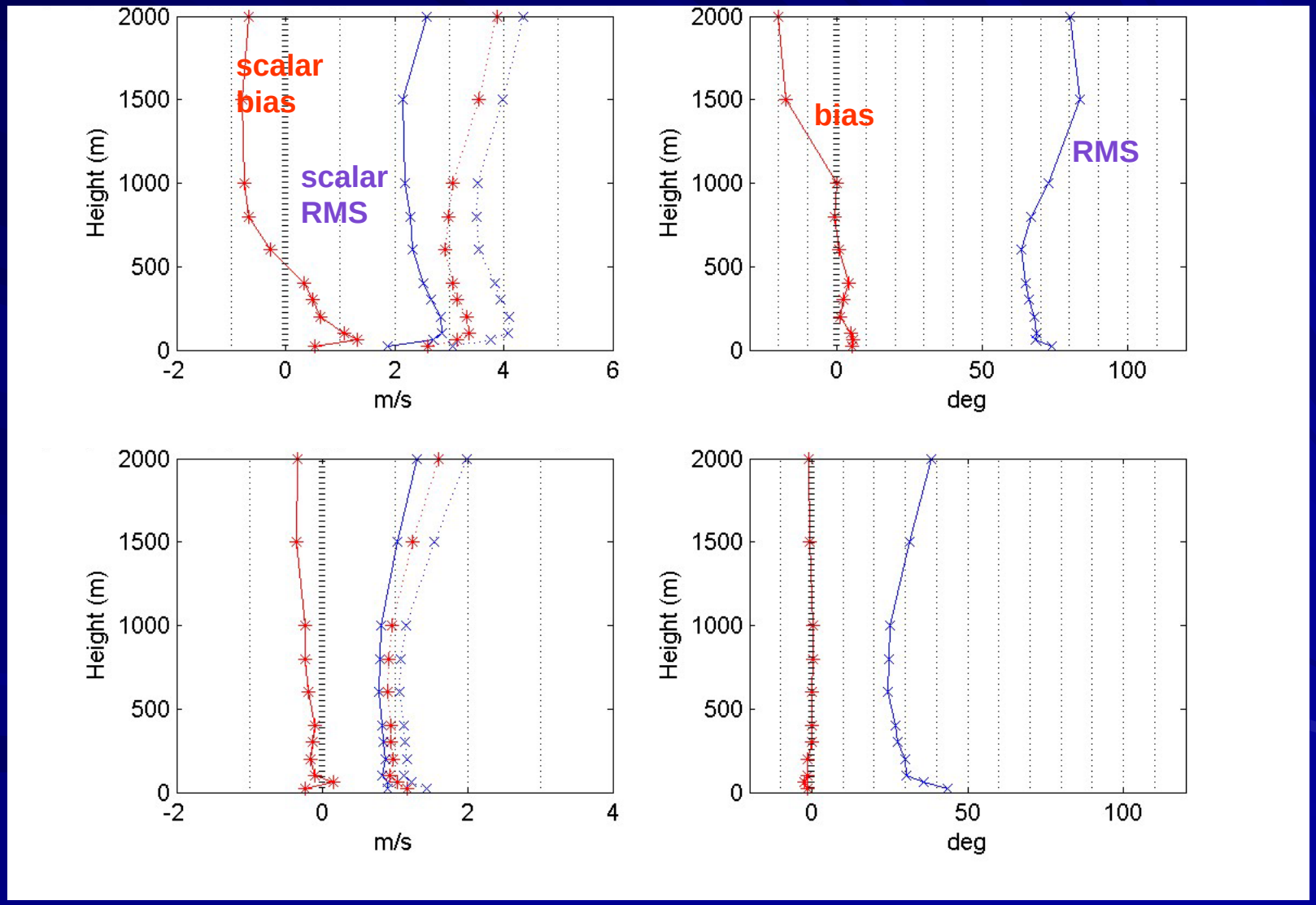
IOP2 Profiler/MM5 statistical comparison

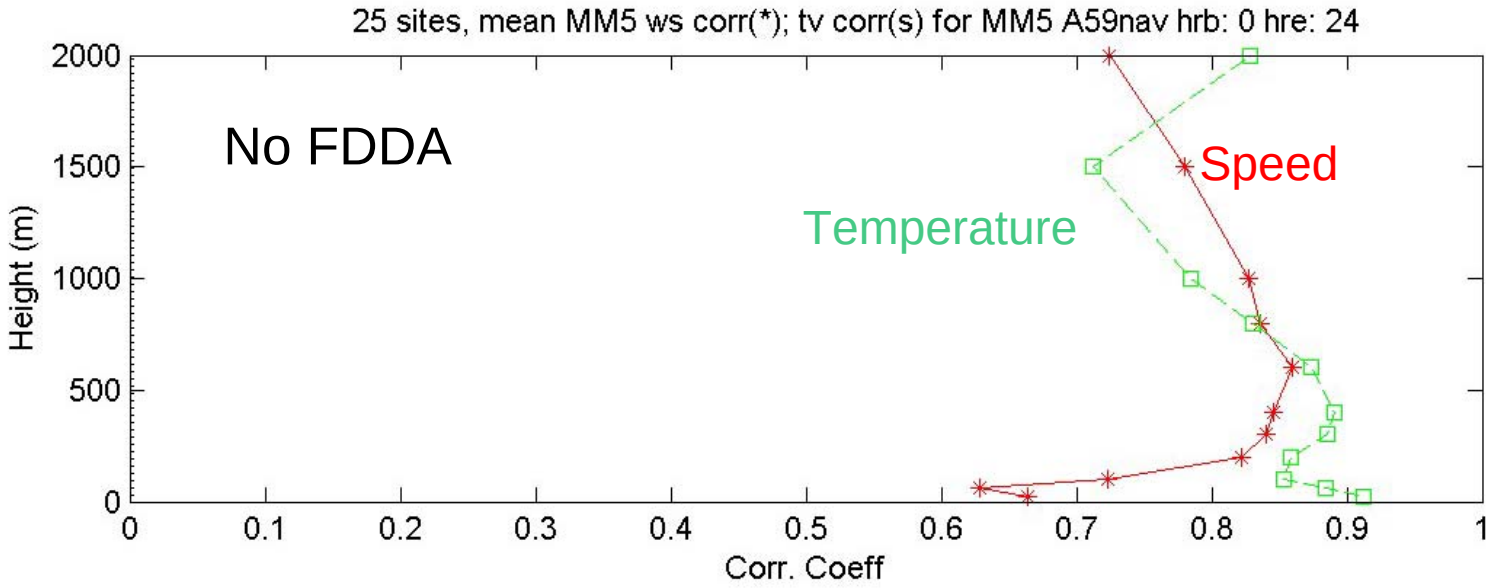
Speed

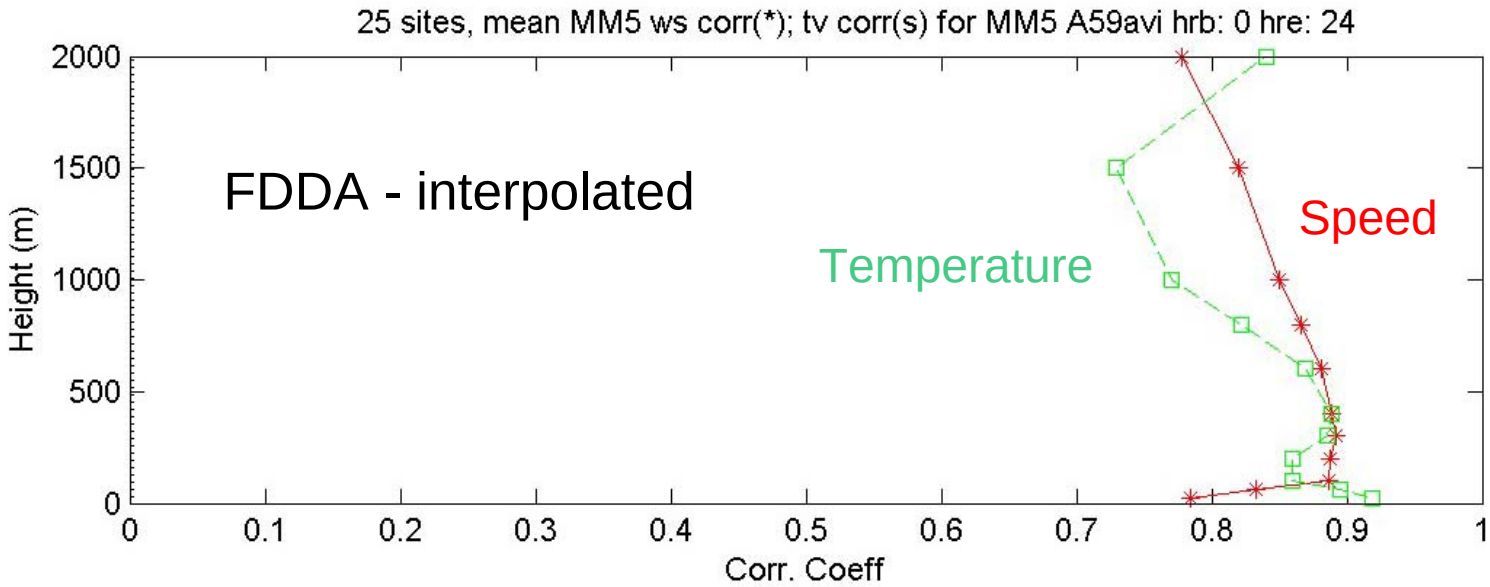
Direction

MM5,
No FDDA

FDDA

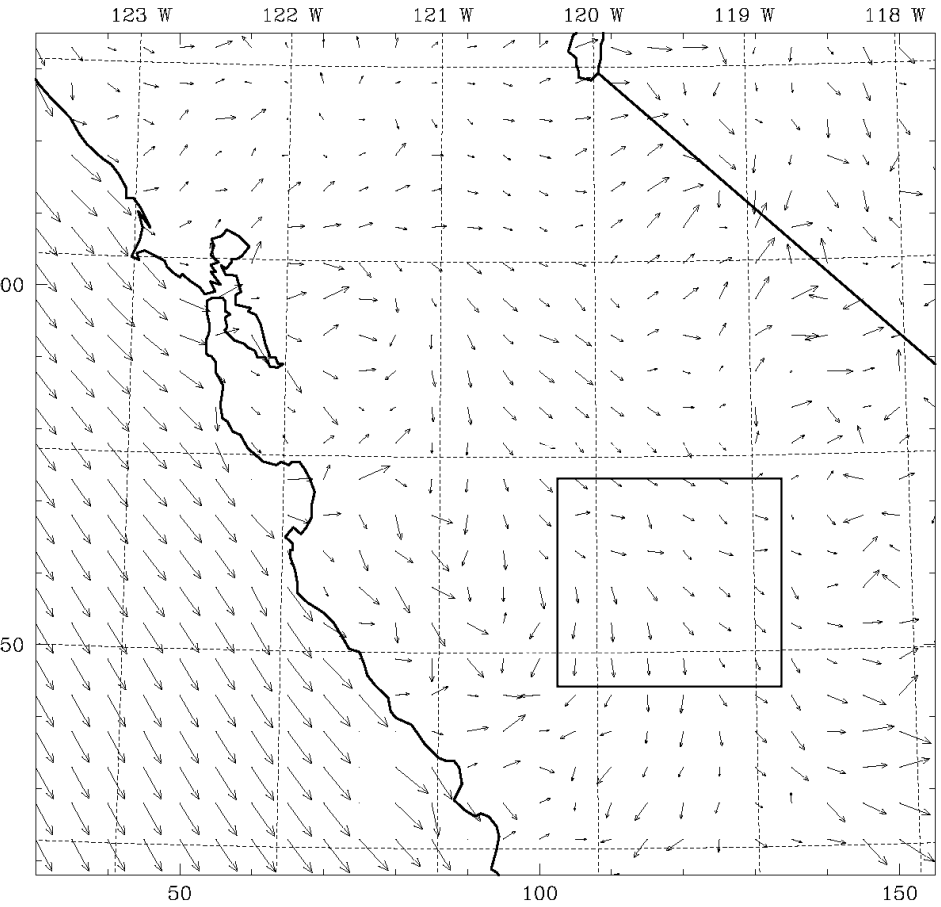


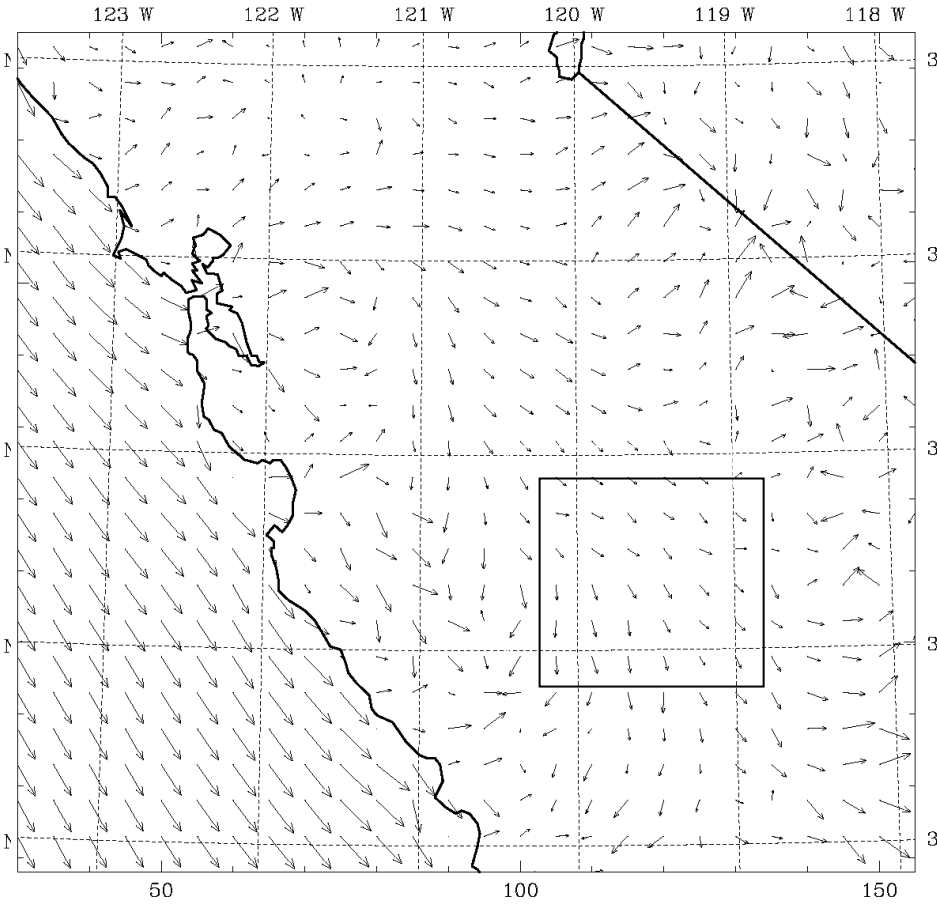




Profiler/MM5 Correlation Coefficients

1800 PDT 30 July 2000
Surface Winds

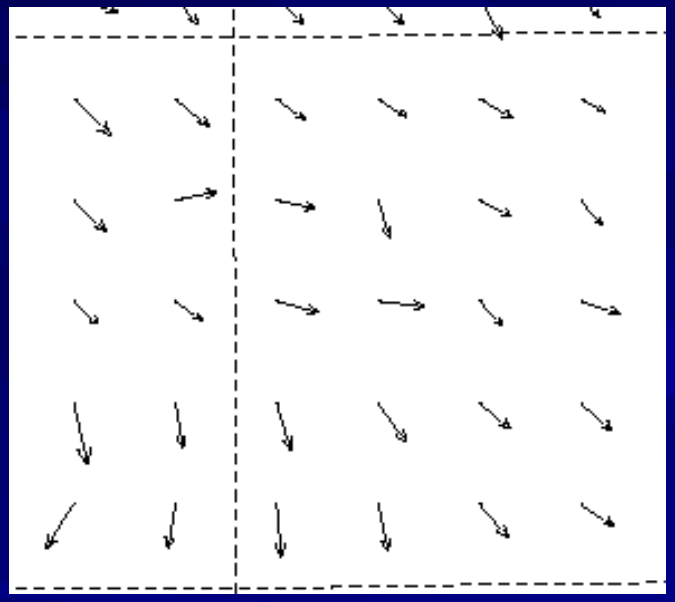




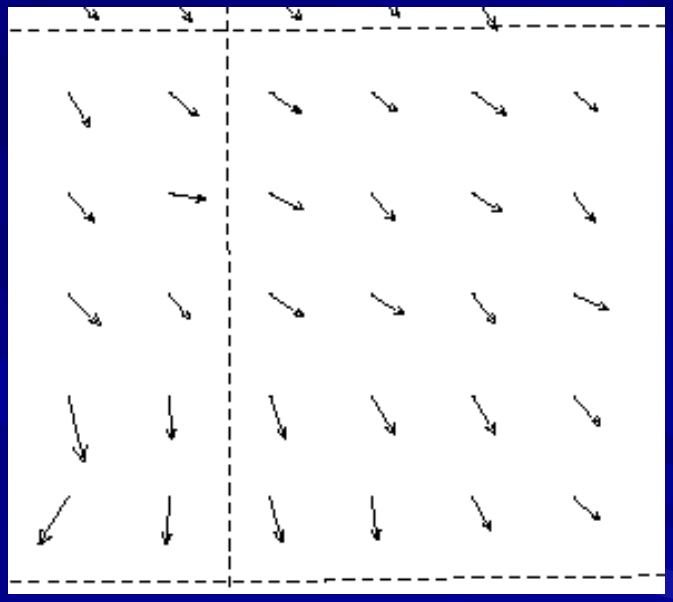
Snapshot output wind

Hour averaged output wind

1800 PDT 30 July 2000
Surface Winds



Snapshot wind

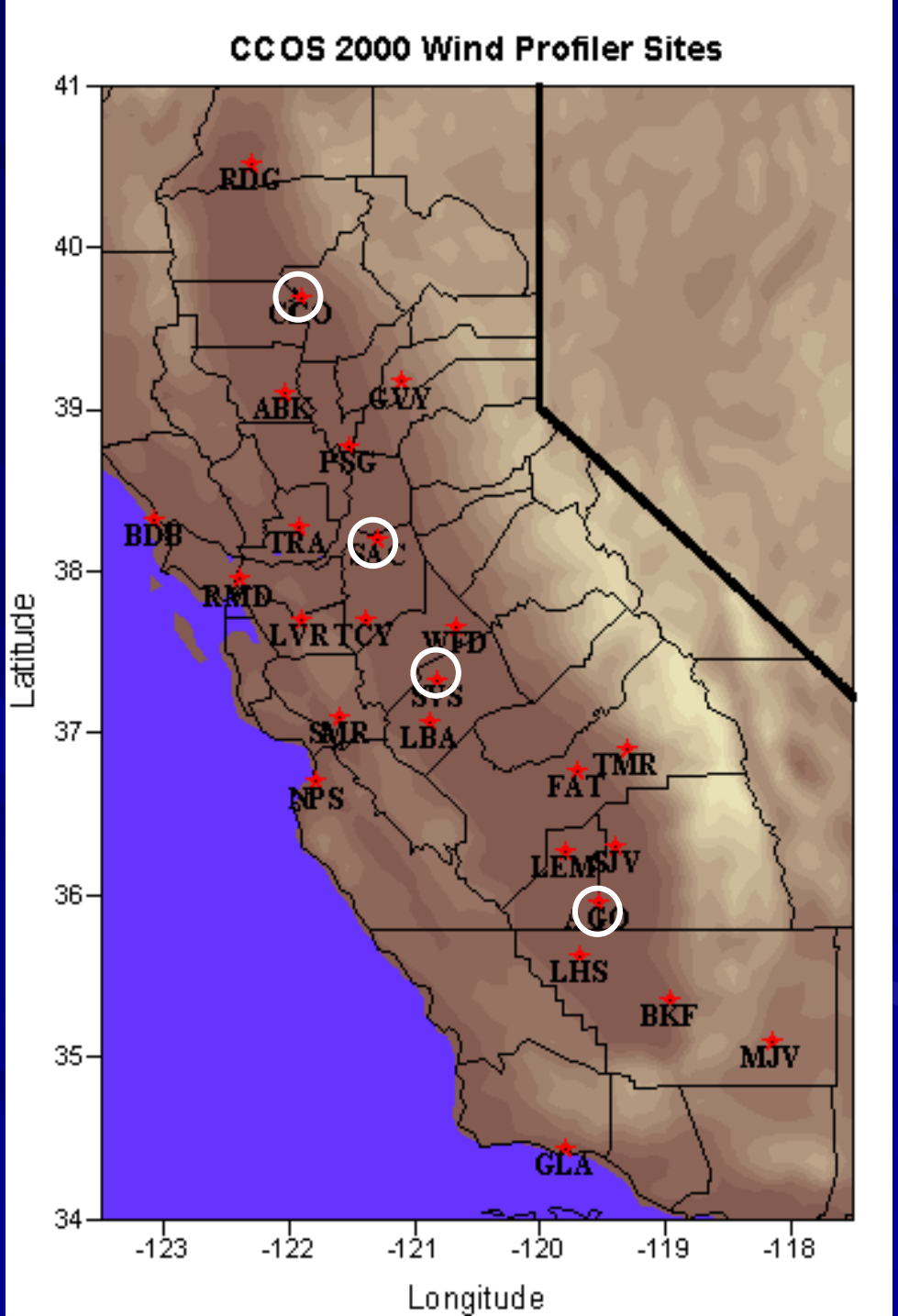


Hour averaged wind

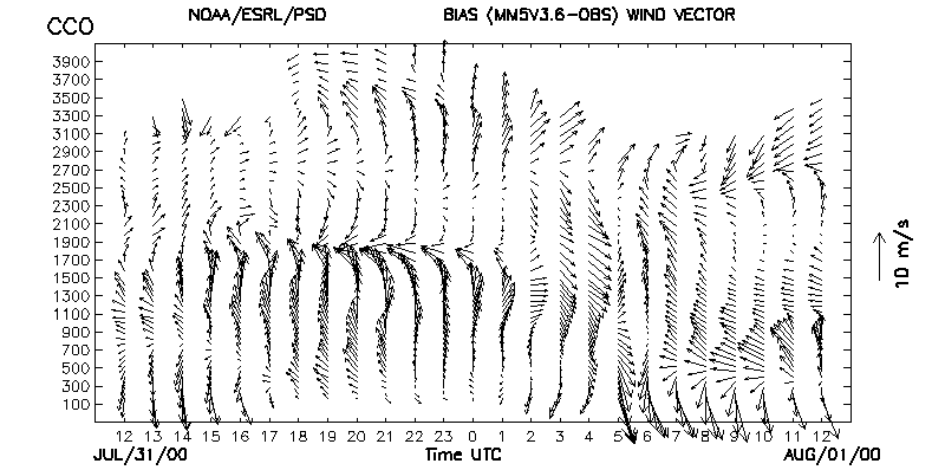
FDDA Data Denial Exp.

FDDA at all sites except:

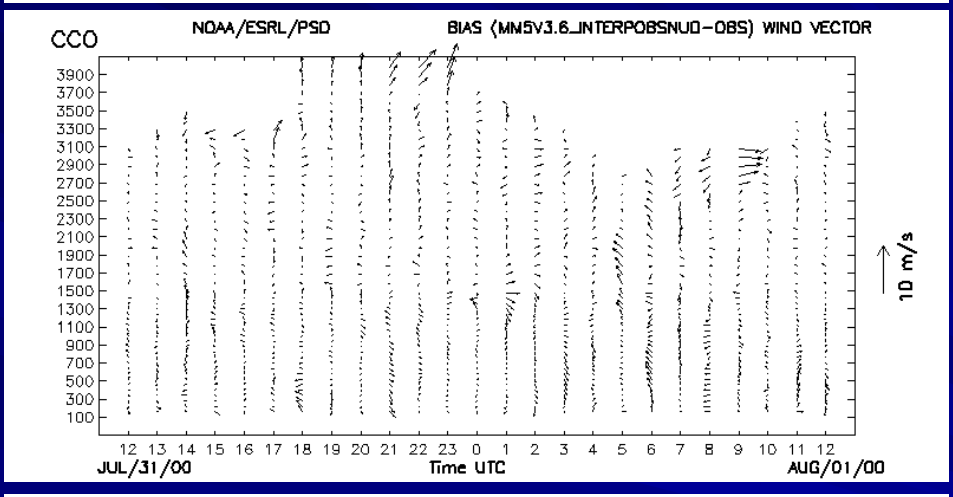
Chico (CCO)
Sacramento (SAC)
Stevenson (SVS)
Angiola (AGO)



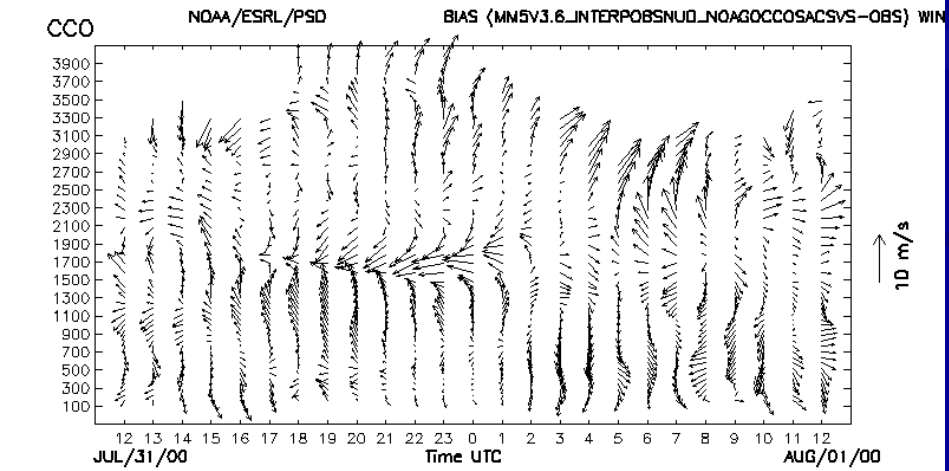
CCO JD213



No FDDA

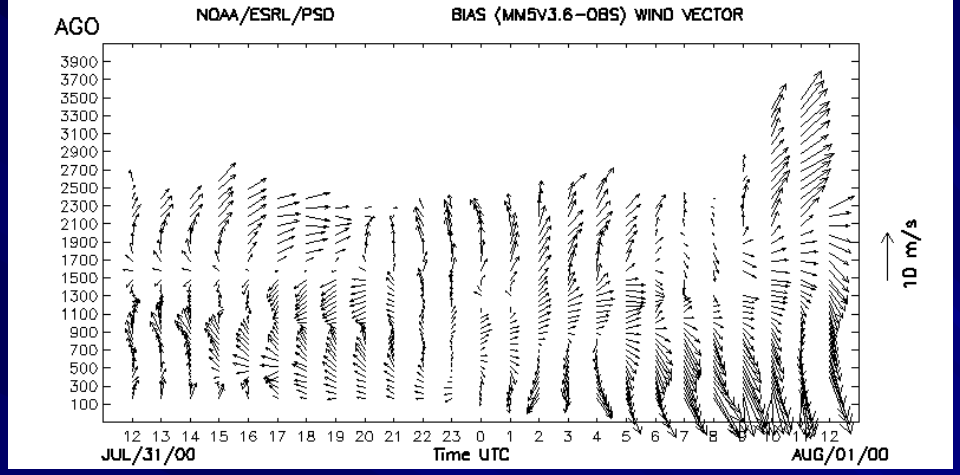


Full FDDA



FDDA – 4 sites

AGO JD213



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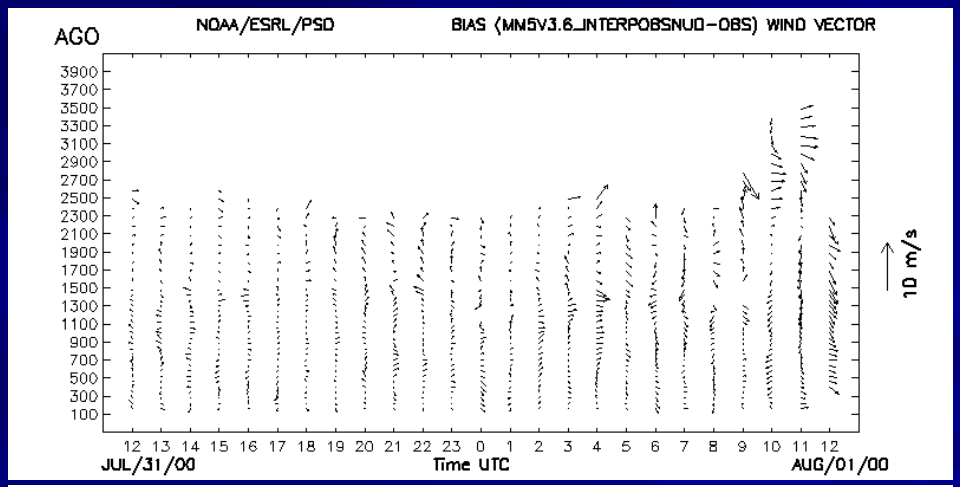
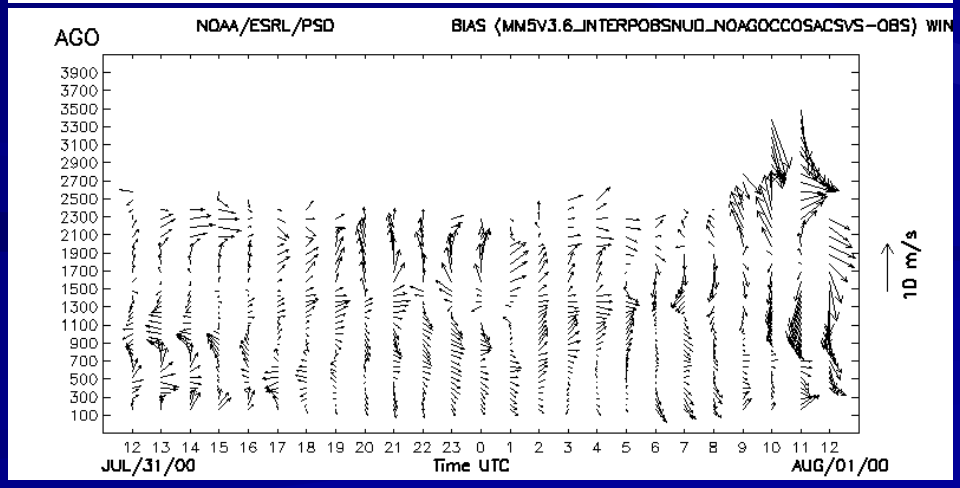
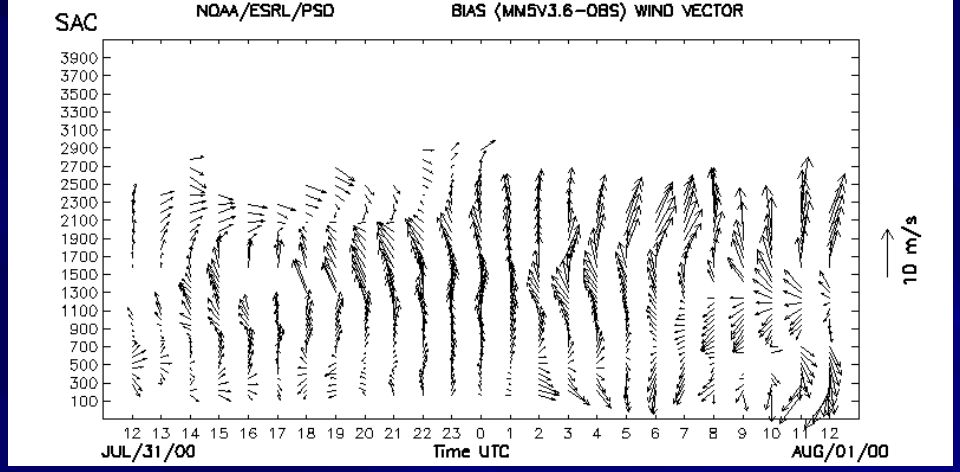


Full FDDA

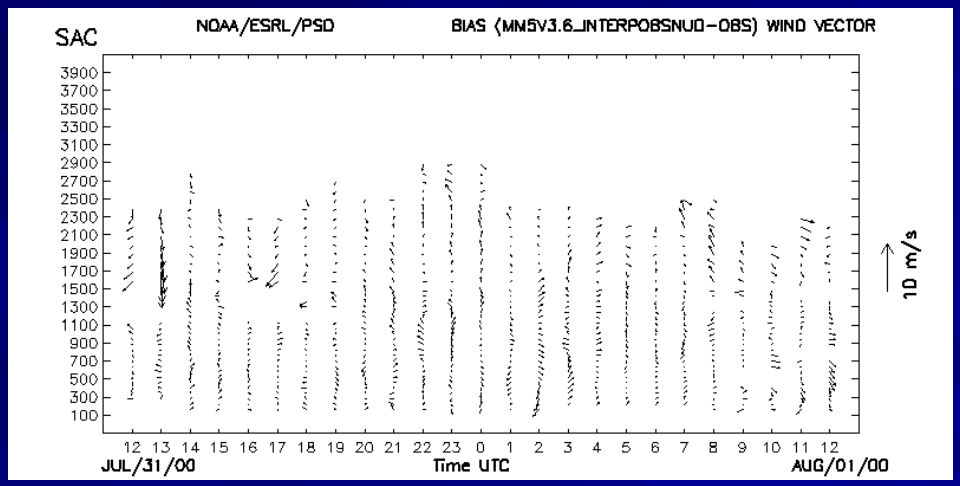


FDDA – 4 sites

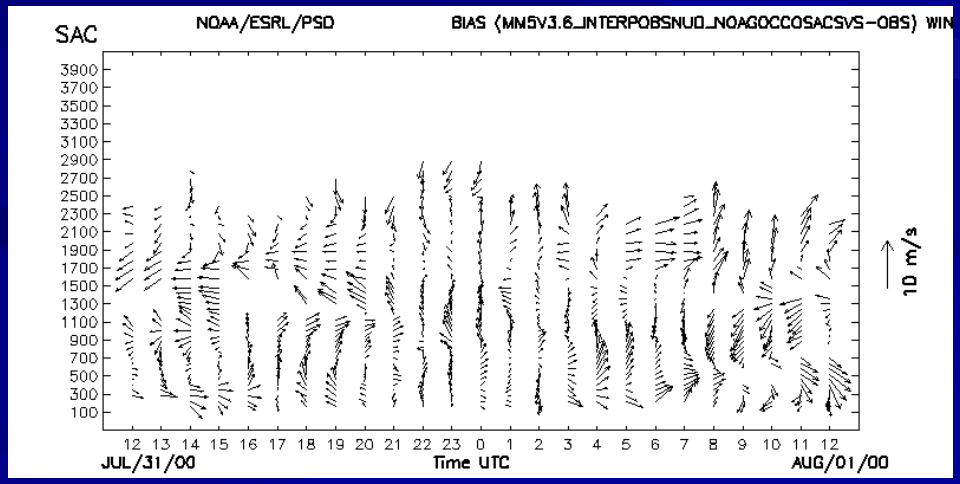
SAC JD213



No FDDA

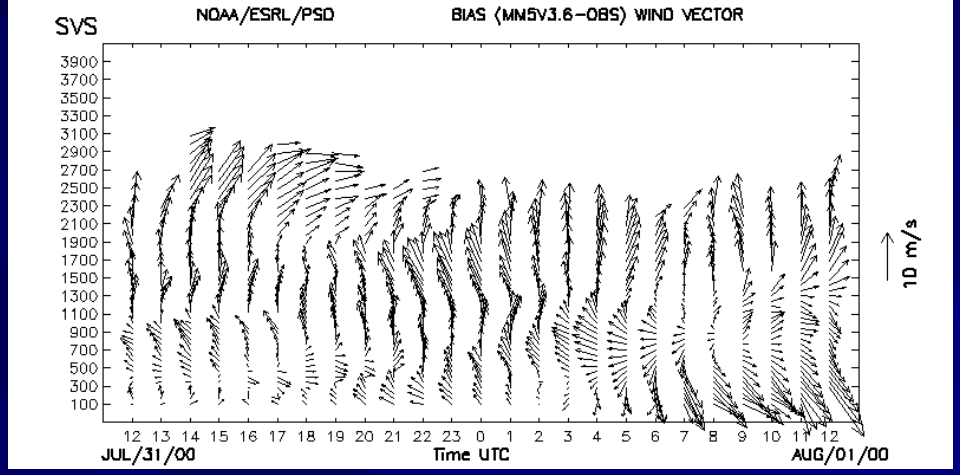


Full FDDA



FDDA – 4 sites

SVS JD213



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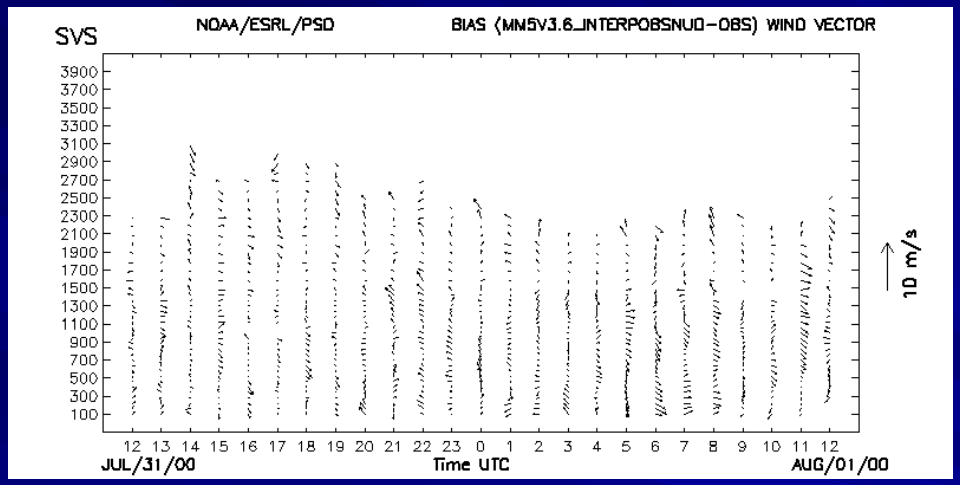
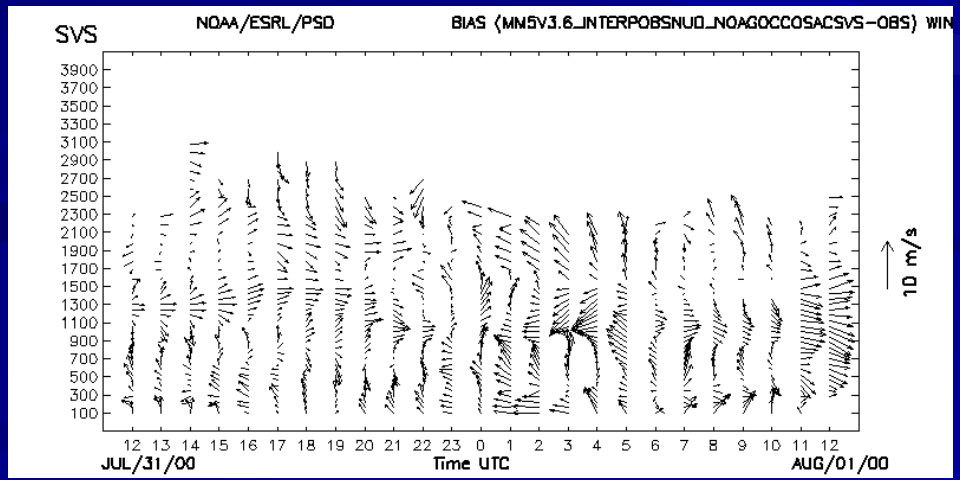
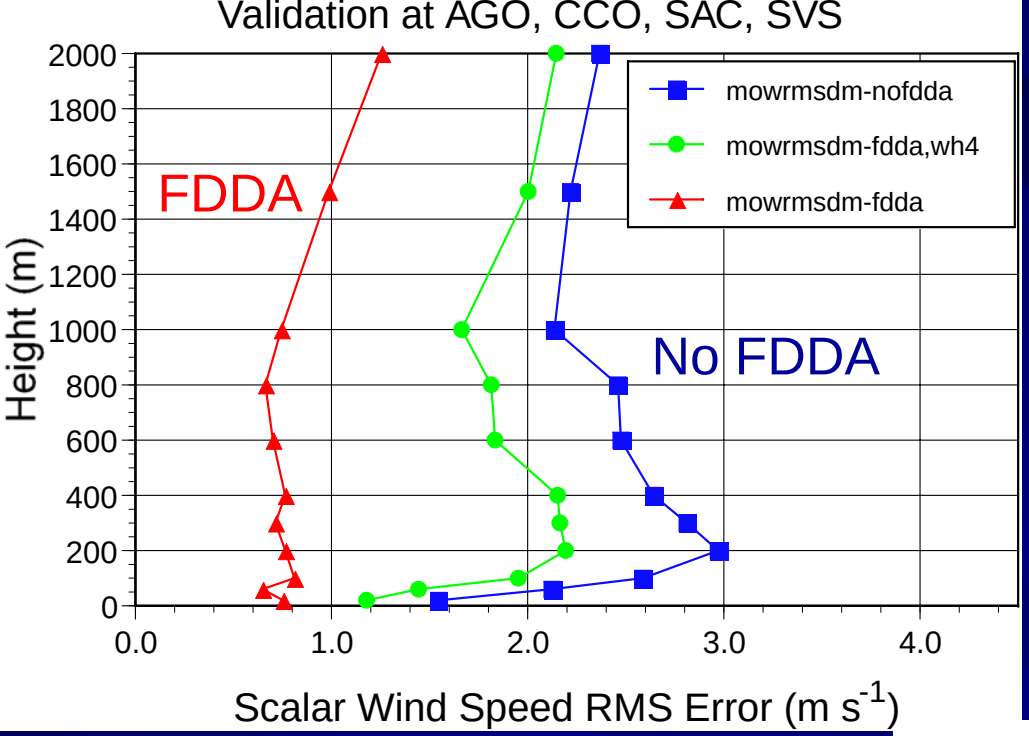


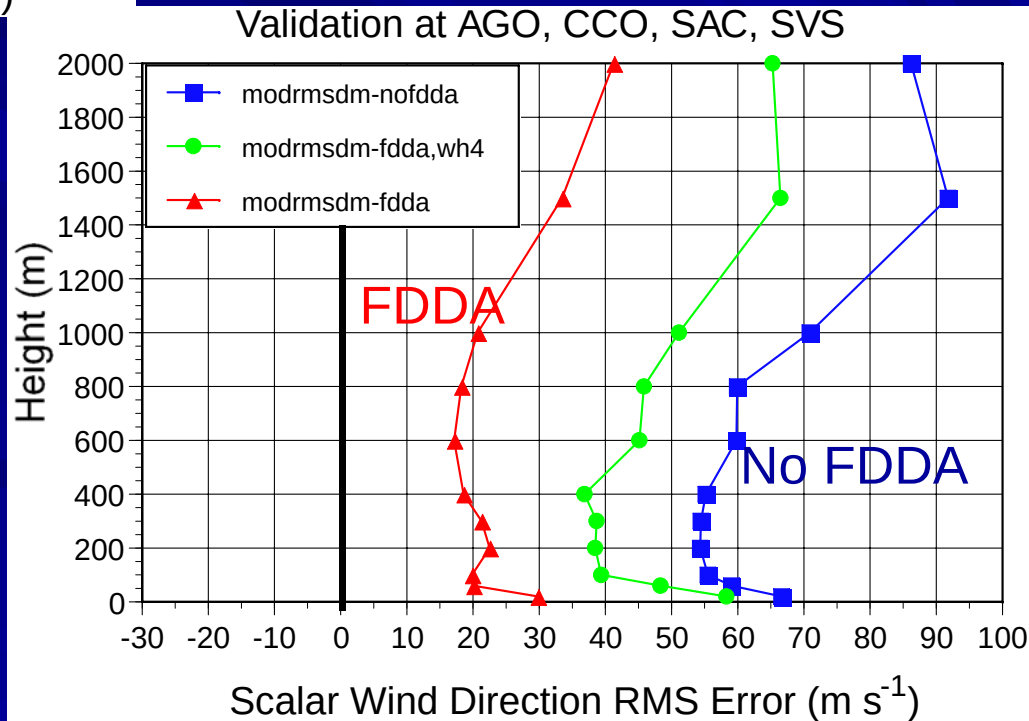
Full FDDA



FDDA – 4 sites

FDDA Data Denial Experiment
IOP2 RMS Errors





Summary

- Eta PBL and NOAH LSM combination give accurate surface temperatures & PBL depths.
- Model clouds and solar radiation were in reasonable agreement with obs, slightly biased towards clear skies.
- Without FDDA, model produced major flow features, e.g. flow splitting, Fresno eddy, Schultz eddy.
- FDDA winds show high statistical agreement with obs.
- Withholding 4 Profilers from FDDA yields statistical agreement at these 4 sites halfway between full FDDA and no FDDA

Summary

Model weaknesses

- Assimilation of dissimilar surface winds in nocturnal stable conditions can produce a noisy surface wind field – effect may be reduced if surface winds were assimilated into more than one model level
- May need larger 4 km domain to include transport from LA basin
- Use of anisotropic terrain-height dependent wind assimilation may provide better winds in canyon areas