VISTAS Meteorological Modeling

Don Olerud

July 29-30, 2003

Introduction

- Model Setup
- Preliminary Results
- The Long and Winding Road
- Results
- Conclusions

Model Setup

- MM5 Version 3.6.1
  - REGRID (3.6.0)
  - LITTLE_R for SFCFDDA files
  - INTERPF uses REGRID files
- Three Sensitivity Episodes
  - January 2-20, 2002 (7-day spin-up)
  - July 13-27, 2001 (7-day spin-up)
  - July 13-21, 1999 (4-day spin-up)

Model Setup (Continued)

- 5.5-day (max) Model Segments
  - 00Z start time
  - 12-hour spin-up per segment
- Linux Cluster using MM5 MPP
  - 8 1.53GHz processors per run
  - Myrinet message passing (19% speed up over regular MPICH)

Model Setup (Continued)

- Linux Cluster (continued)
  - Cycles provided by the MCNC Center for Networked Information Discovery and Retrieval (CNIDR)
  - PX MPP code obtained from EPA researcher
  - KF2 code updated for MPP by Dr. Jack Kain
  - Other bugs fixed as needed

Preliminary Results

- January 2-20, 2002 case
  - Pleim-Xiu soil model
  - Dec 26 00Z initialization (ISMRD=2)
  - ISMRD=1 for subsequent segments
- Significant Cold Bias
  - 12 km VISTAS region
    - -2.08 K 1.5m t bias (2.82 error)
    - -1.08 K layer 1 t bias (2.49 error)
  - 36 km VISTAS region
    - -1.67 K 1.5m t bias (2.65 error)
    - -0.52 K layer 1 t bias (2.29 error)

Preliminary Results (continued)

- 36 km MIDWEST region
  - -3.05 (3.31) 1.5m temps
  - -1.67 (2.23) layer 1 temps
- 36 km WRAP region
  - -1.39 (2.90) 1.5m temps
  - 0.21 (2.69) layer 1 temps
- No problems with QV, Winds, or Precipitation

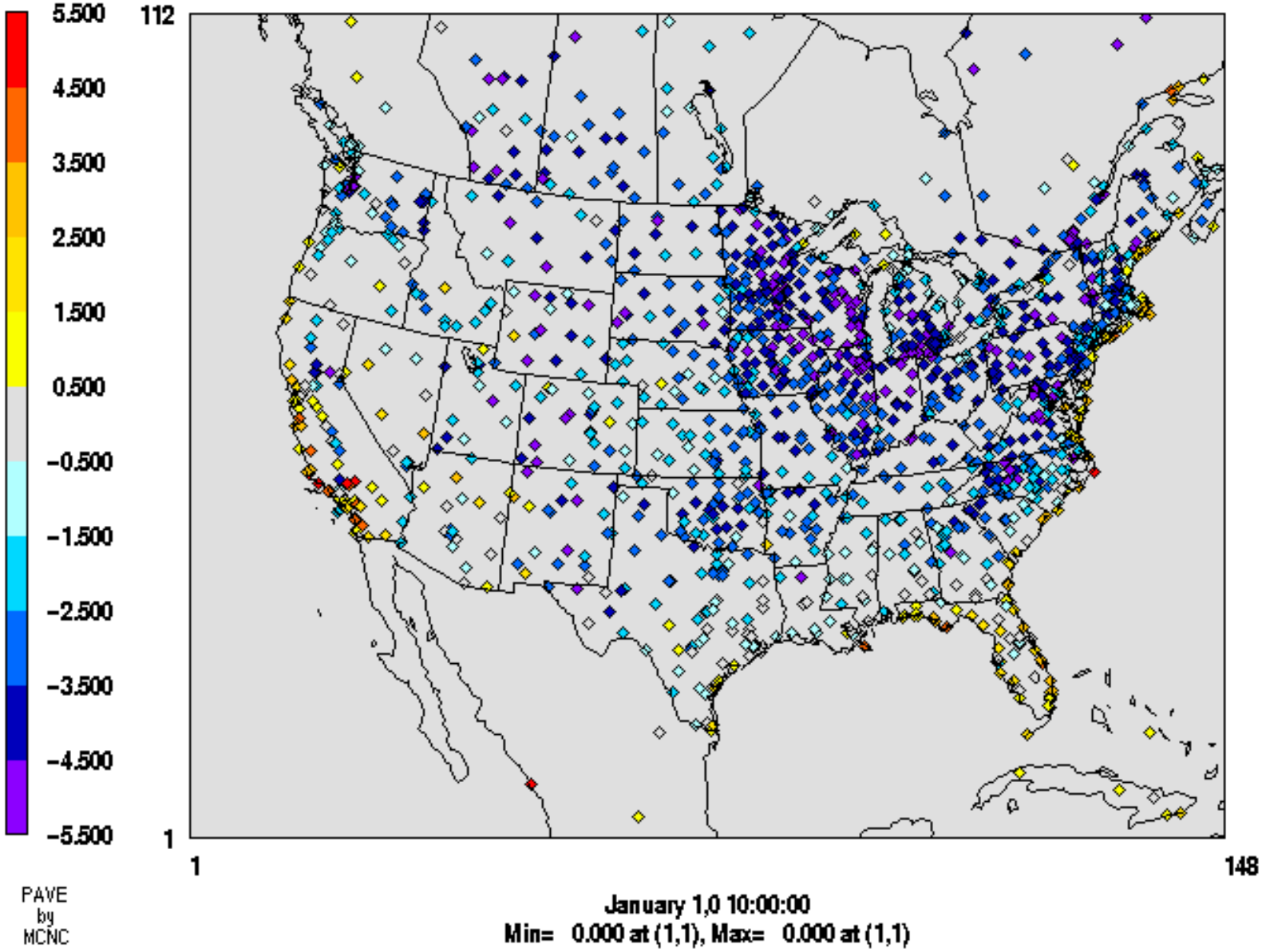
Assessing Model Performance

- Statistical "Benchmarks":
  - Wind Speed
    - RMSE <= 2 m/s
    - Bias <= +/- 0.5 m/s
    - IA >= 0.6
  - Wind Direction
    - Gross Error <= 30 deg
    - Bias <= +/- 10 deg
  - Temperature
    - Gross Error <= 2 K
    - Bias <= +/- 0.5 K
    - IA >= 0.8
  - Humidity
    - Gross Error <= 2 g/kg
    - Bias <= +/- 1 g/kg
    - IA >= 0.6

Source: Environ Report: *Meteorological Modeling and Performance Evaluation of September 13-19th Ozone Episode*

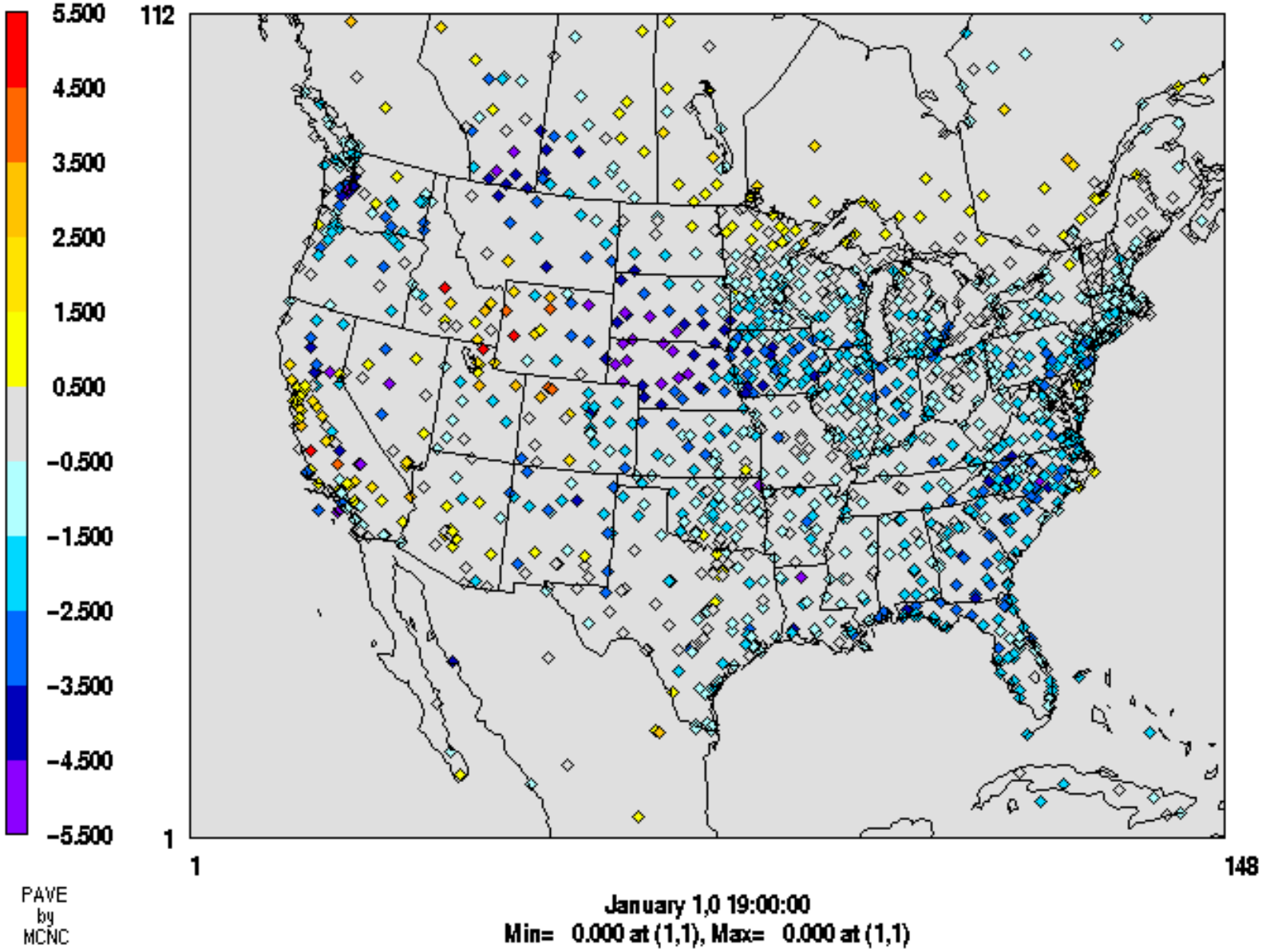
Temperature Bias

(Episode 1, Full: 36km, px_acm, 1.5m)



Temperature Bias

(Episode 1, Full: 36km, px_acm, 1.5m)



The Long and Winding Road

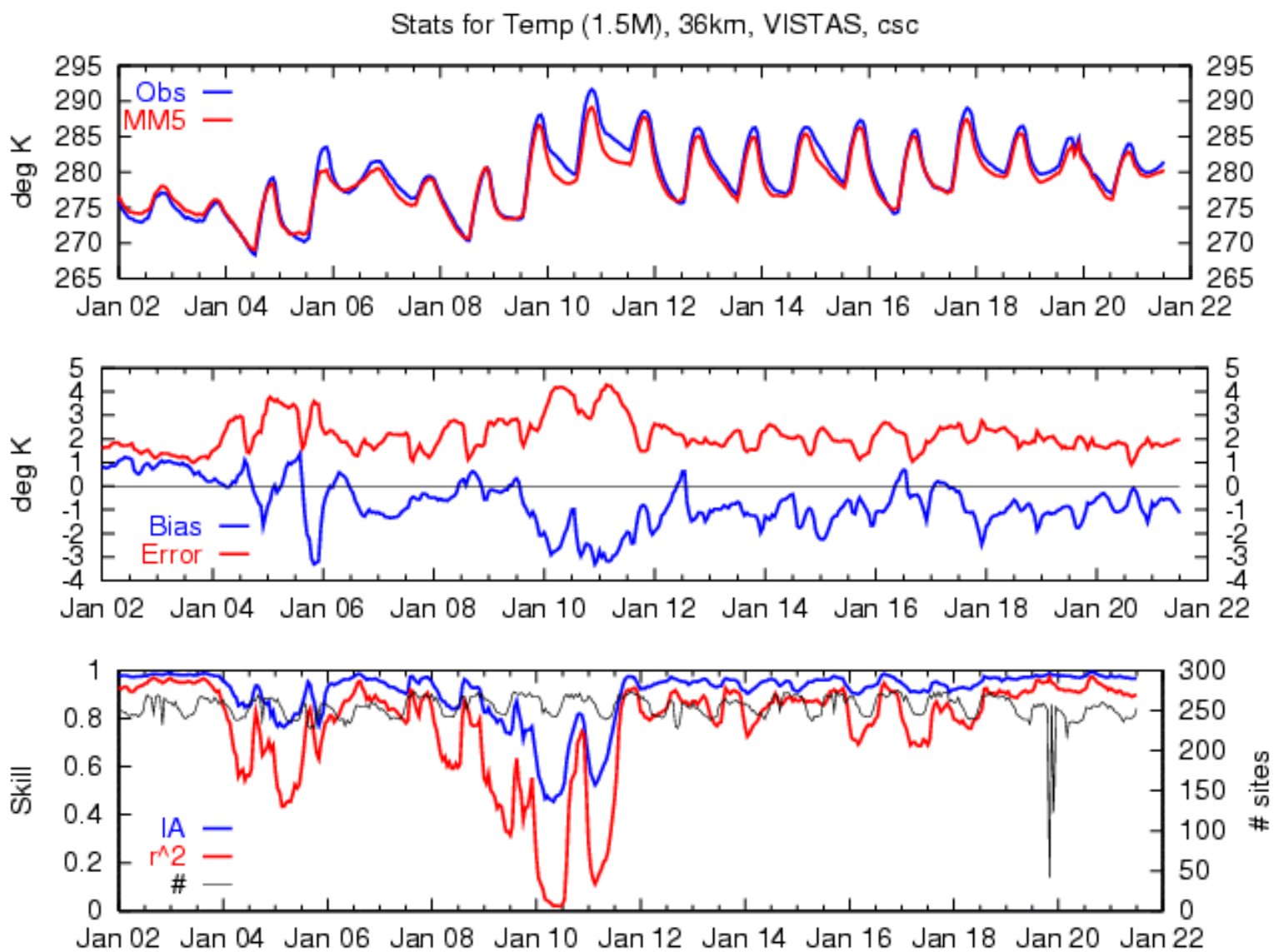
- Two Obvious Questions
  - Do others see something similar?
  - Why such a strong cold bias?
- 2001 Annual Run for OAQPS
  - Includes January 2002 analyses
  - Jan-Feb results less biased, per correspondence with Pat Dolwick (OAQPS/NOAA)
- Jan 2002 period remodeled by EPA contractor for ORD

The Long and Winding Road (Continued)

- EPA rerun
  - Followed Alpine's settings as much as possible
  - Used MM5 v3.6.0
    - ISSTVAR = 1
    - Mixed phase moisture physics
    - 36 km RPO grid
  - Runs supposedly cold started on Dec 31 12Z using ISMRD=2 (Soil moisture initialized from ETA analysis via REGRID)
  - No stats available

The Long and Winding Road (Continued)

- Acquired EPA rerun results
  - Cold bias exists, but less pronounced
    - -0.74 K 1.5m t bias (2.15 error)
    - 0.24 K layer 1 t bias (2.10 error)
  - My preliminary results:
    - -1.67 K 1.5m t bias (2.65 error)
    - -0.52 K layer 1 t bias (2.29 error)


Stats for Temp (1.5M), 36km, VISTAS, csc
deg K
Obs
MM5
295
290
285
280
275
270
265
Jan 02
Jan 04
Jan 06
Jan 08
Jan 10
Jan 12
Jan 14
Jan 16
Jan 18
Jan 20
Jan 22
deg K
Bias
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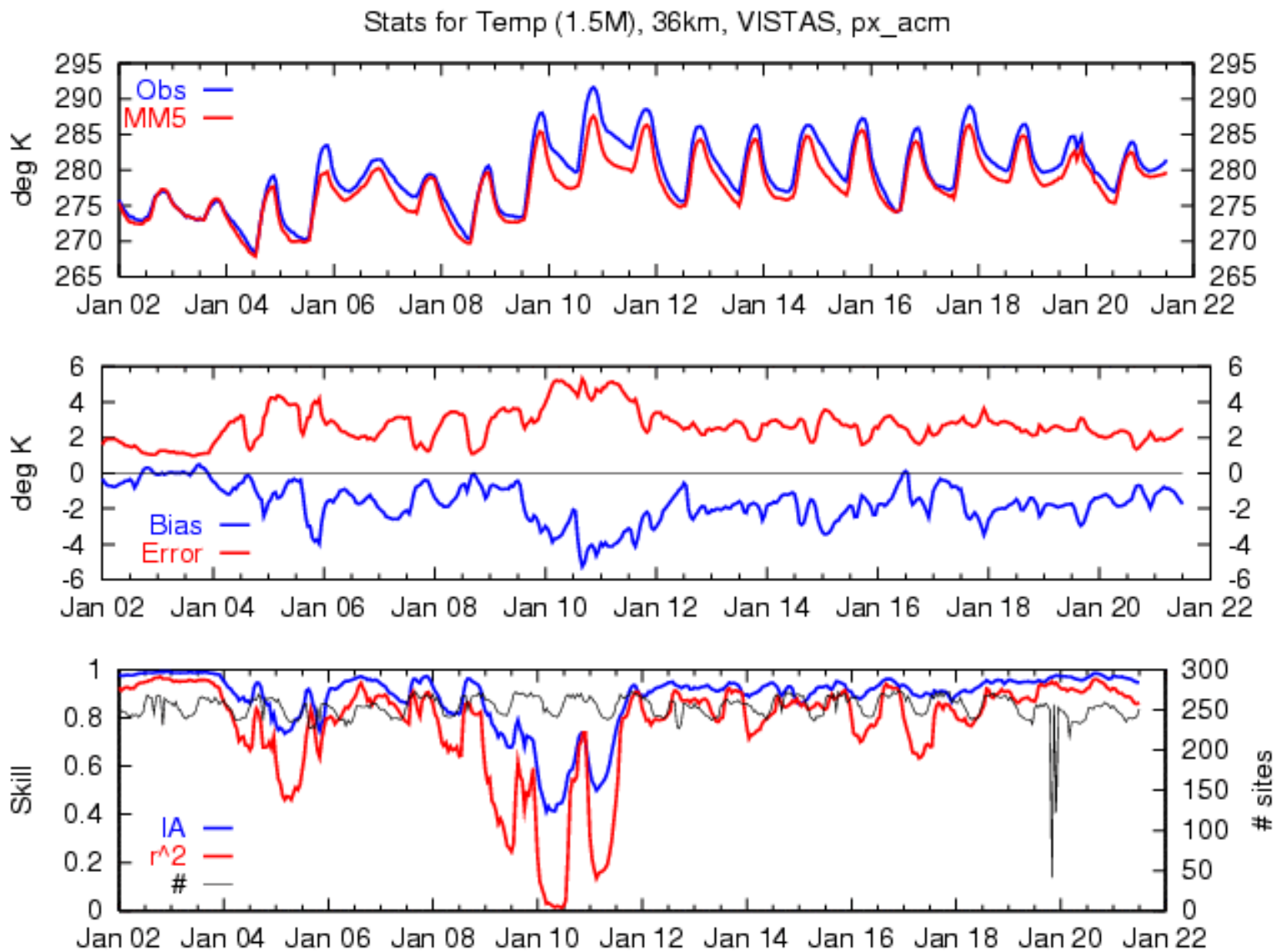
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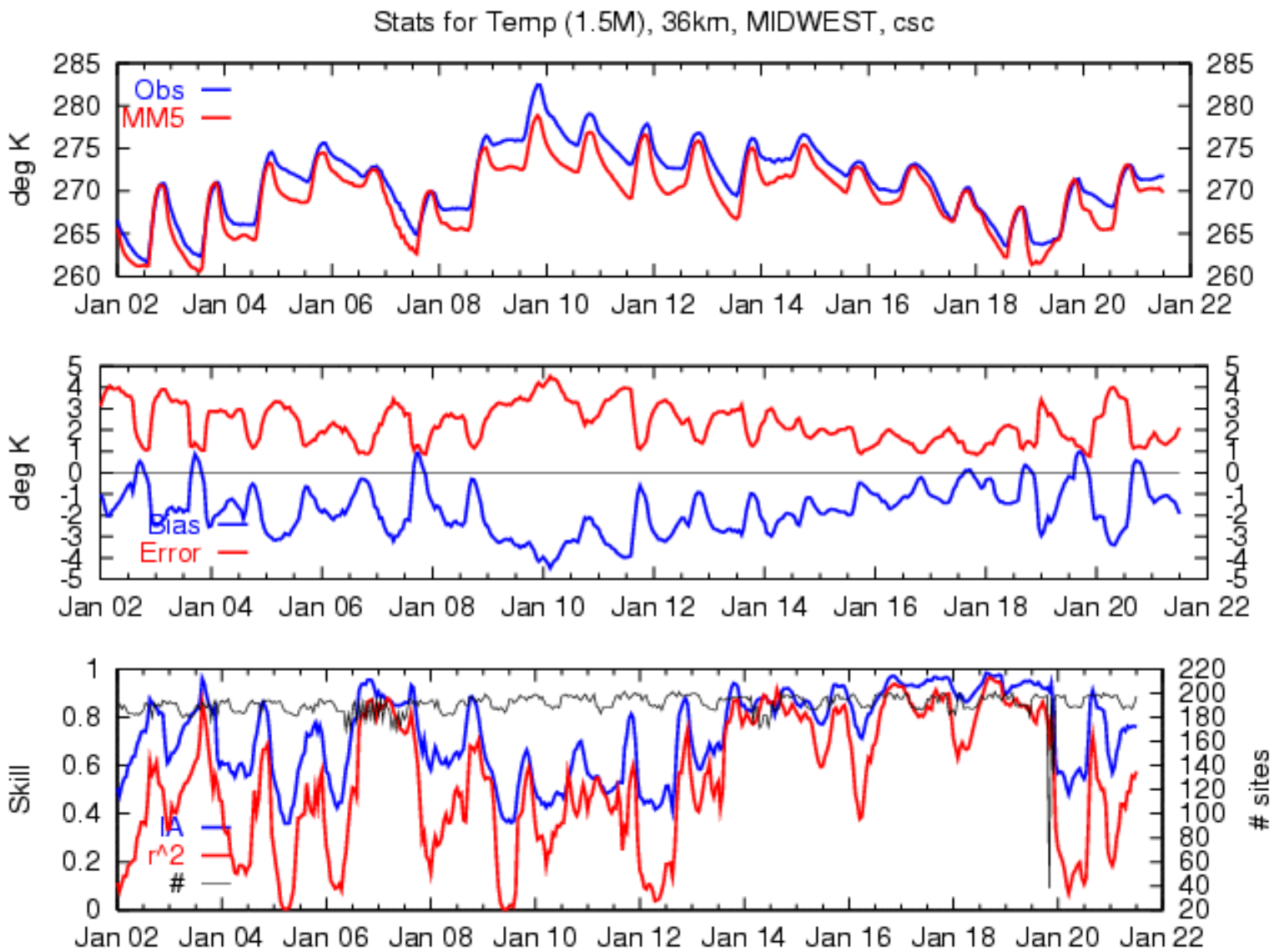
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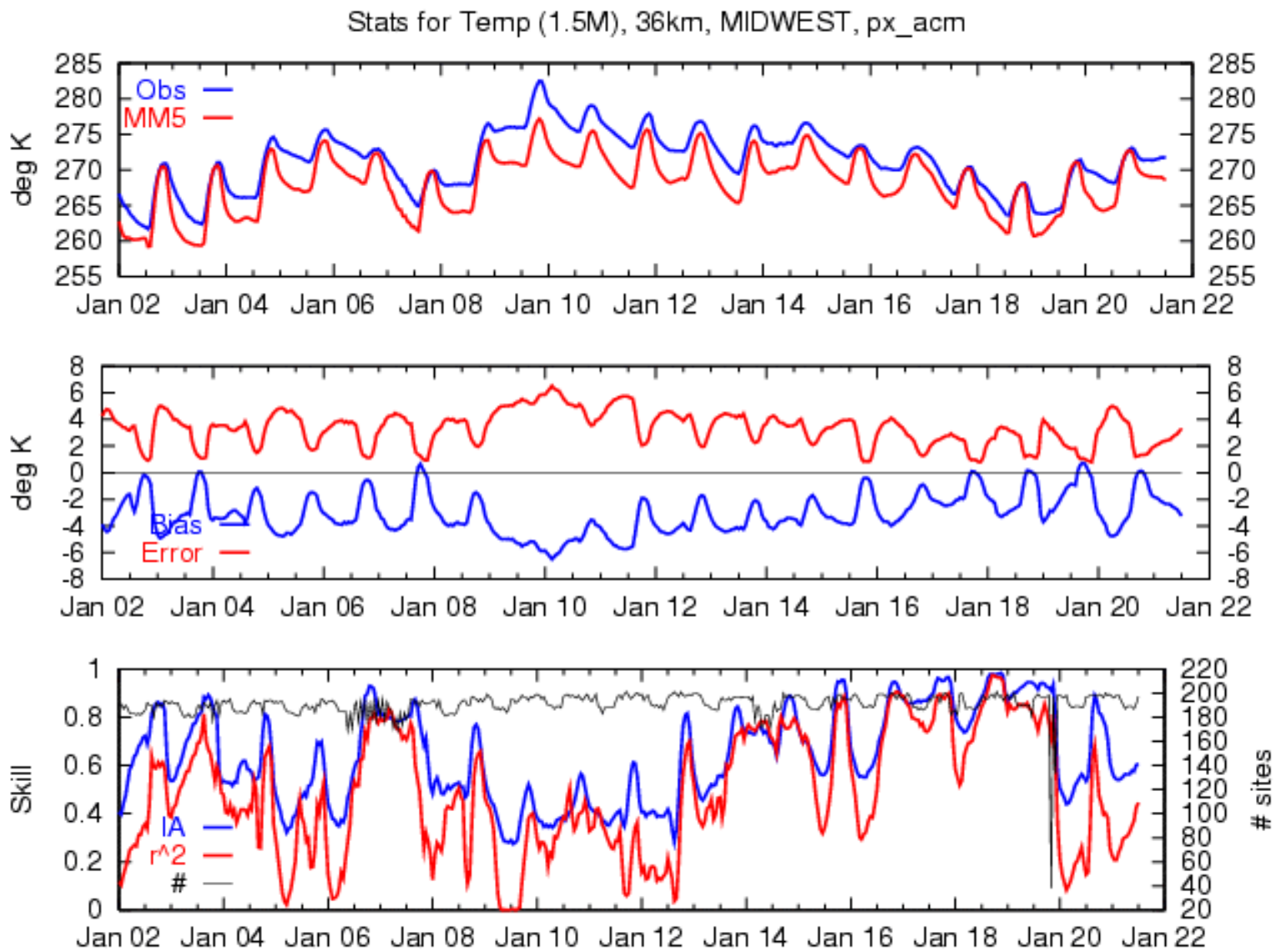
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The Long and Winding Road (Continued)

- Differences in Modeling Systems (EPA rerun listed first)
  - MM5 v3.6.0 vs MM5 v3.6.1
  - RAWINS vs LITTLE_R
  - Rawins>Interpf vs Regrid>Interpf
  - 3.0E-4 nudging strength vs 2.5E-4 (1.0)
  - RADFREQ=15 vs RADFREQ=30
  - KF vs KF2
  - OpenMP vs MPP
  - Dec 31 12Z start vs Dec 26 00Z start

The Long and Winding Road (Continued)

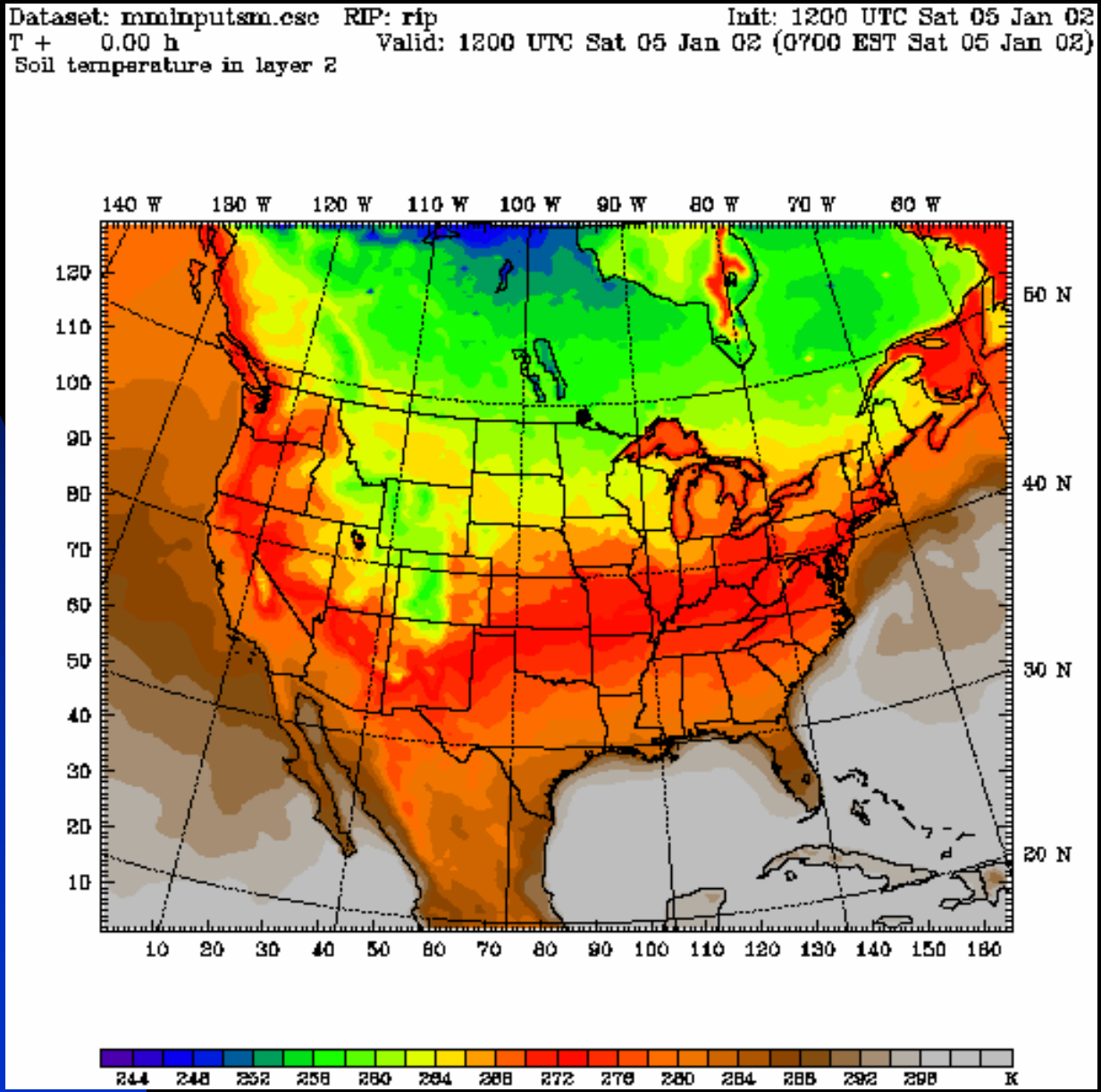
- Test 1: Complete rerun
  - RAWINS, not LITTLE_R
  - Rawins>Interpf, not Regrid>Interpf
  - 3.0E-4, 1.5E-4 (36, 12) nudging strength vs 2.5E-4, 1.0E-4
- Results discouraging
  - Bias results changed by <0.05K
  - Wind speed IA slightly degraded
- RADFREQ test aborted after 7 days due to lack of positive response

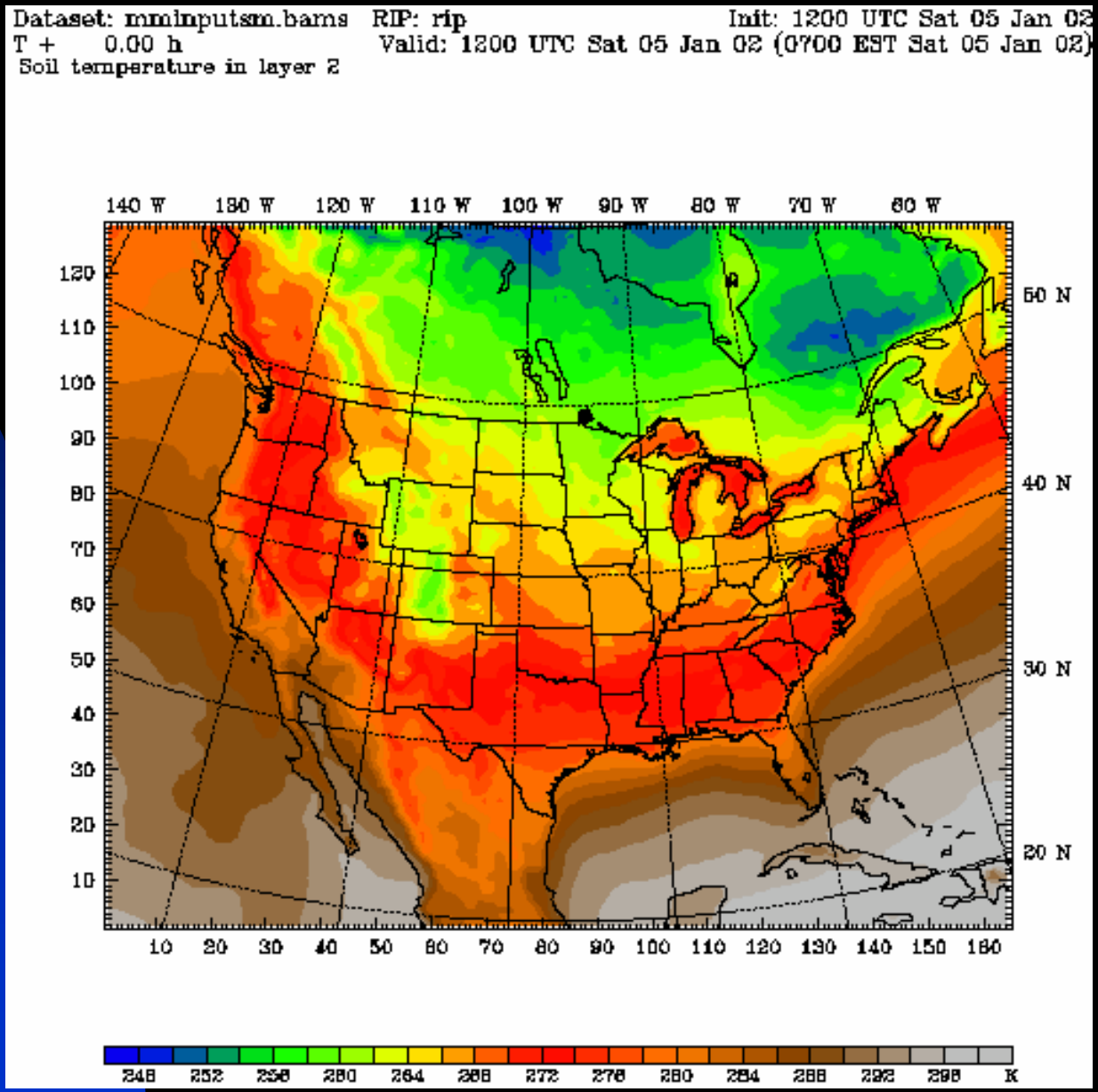
The Long and Winding Road (Continued)

- Obtained MM5 inputs from EPA contractor for Jan 5, 2002
  - Reran case using v3.6.1 MPP
  - Results virtually identical
    - 1.5m temps differ by ~0.002K
  - Problem must stem from preprocessing system, not v3.6.1 or MPP
- Generated new model inputs for Jan 5 segment
  - Can now compare input fields directly
  - Only significant differences were that my fields rightly contained sea ice and constant SST's

The Long and Winding Road (Continued)

- Reran Dec 31 segment (Start time issue?)
  - Used ipxncar to provide continuous soil fields to Jan 5 segment, which was rerun
  - New results are still too cold
  - MCIP2 output available for EPA rerun and my test runs
  - Fields are now easily viewed via PAVE
- Only fields significantly different are soil temperatures in both layer 1 and (especially) layer 2
  - SOIL T2 comes from res_temp (interpf)


Dataset: mminputsm.esc RIP: rip
Init: 1200 UTC Sat 05 Jan 02
T + 0.00 h
Valid: 1200 UTC Sat 05 Jan 02 (0700 EST Sat 05 Jan 02)
Soil temperature in layer 2
140 W 130 W 120 W 110 W 100 W 90 W 80 W 70 W 60 W
120 110 100 90 80 70 60 50 40 30 20 10
50 N 40 N 30 N 20 N
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
244 248 252 256 260 264 268 272 276 280 284 288 292 296 K

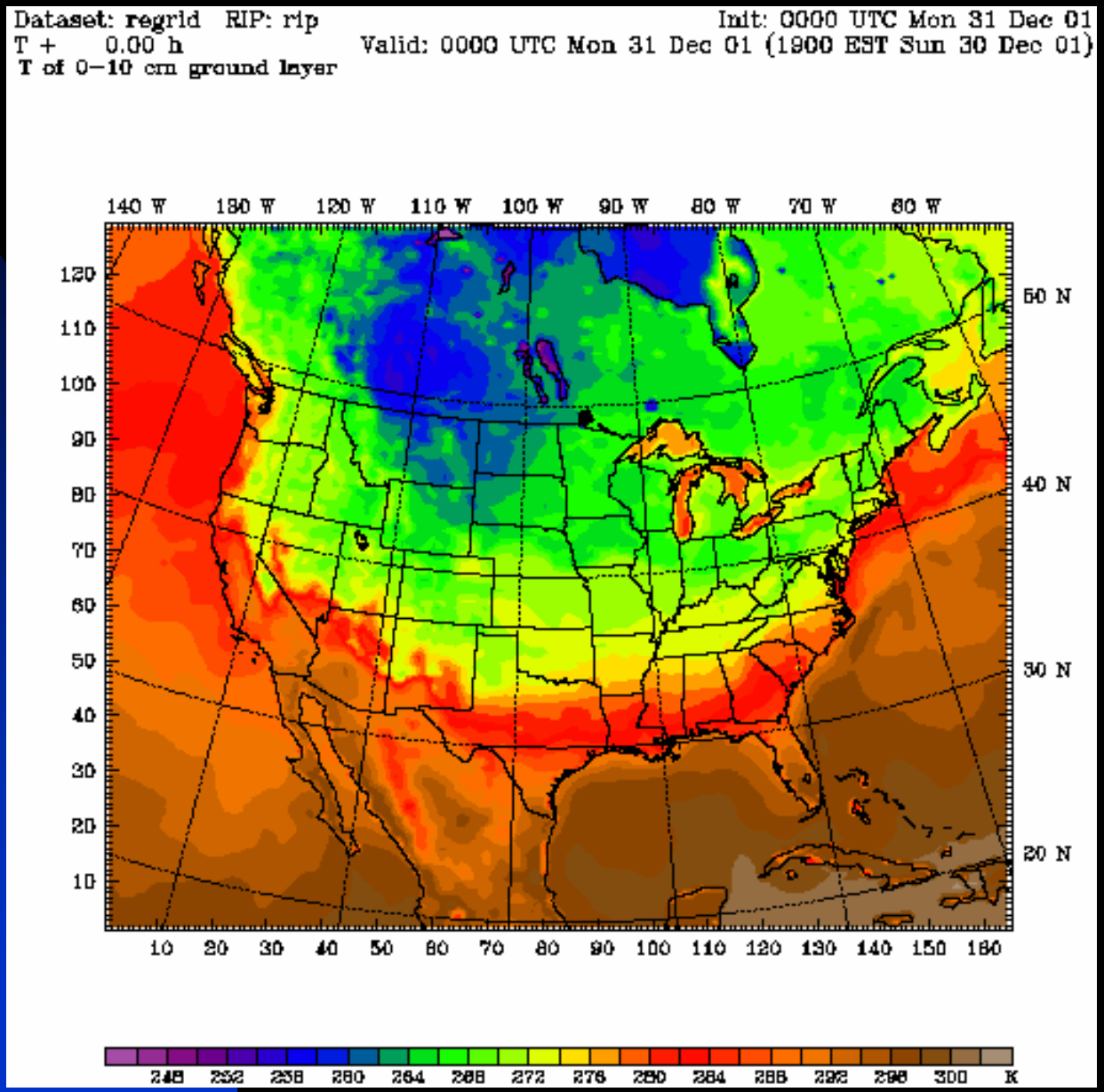

Dataset: mminputsm.bams RIP: rip Init: 1200 UTC Sat 05 Jan 02
T + 0.00 h Valid: 1200 UTC Sat 05 Jan 02 (0700 EST Sat 05 Jan 02)
Soil temperature in layer 2
140 W 130 W 120 W 110 W 100 W 90 W 80 W 70 W 60 W
120 110 100 90 80 70 60 50 40 30 20 10
50 N 40 N 30 N 20 N
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
248 252 256 260 264 268 272 276 280 284 288 292 296 K

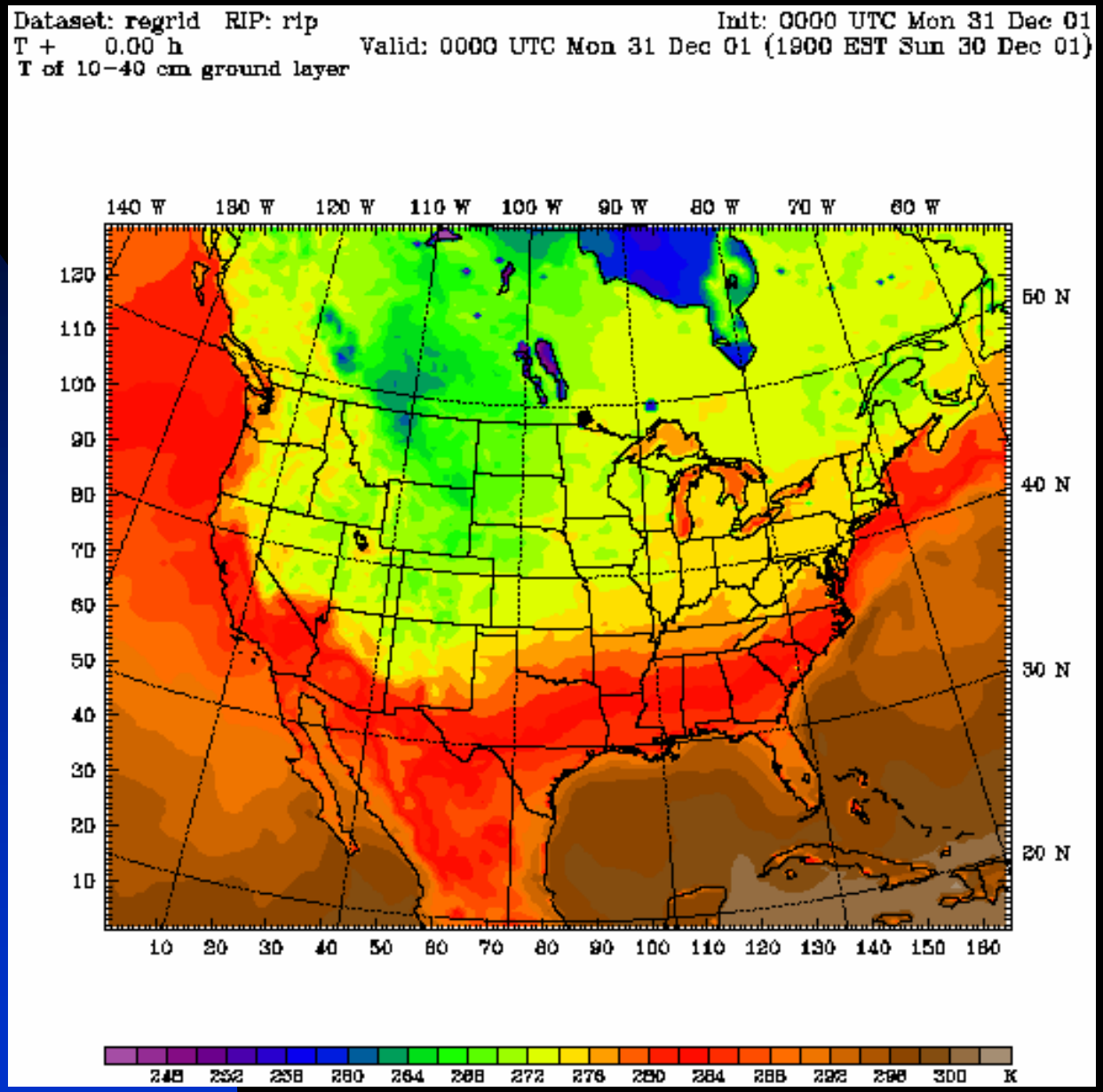
The Long and Winding Road (Continued)

- Numerous INTERPF tests
  - Used slightly different deck options
  - Reprocessed with v3.6.0 and v3.5.4
  - No discernable differences
- Reran IPXNCAR with EPA version of the code
  - No differences
- Reran REGRID
  - Took out climatological maximum snow albedo (RDMAXALB)
    - No significant effect

The Long and Winding Road (Continued)

- Informed that EPA rerun was cold-started using ISMRD=0
  - Significant cold bias persists
- ETA soil levels
  - 0-10 cm
  - 10-40 cm
  - 40-100 cm
  - 100-200 cm
- P-X soil levels
  - Surface
  - 0-100 cm


Dataset: regrid RIP: rip
T + 0.00 h
T of 0-10 cm ground layer
Init: 0000 UTC Mon 31 Dec 01
Valid: 0000 UTC Mon 31 Dec 01 (1900 EST Sun 30 Dec 01)
140 W 130 W 120 W 110 W 100 W 90 W 80 W 70 W 60 W
120 110 100 90 80 70 60 50 40 30 20 10
50 N 40 N 30 N 20 N
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
248 252 256 260 264 268 272 276 280 284 288 292 296 300 K


Dataset: regrid RIP: rip
Init: 0000 UTC Mon 31 Dec 01
T + 0.00 h
Valid: 0000 UTC Mon 31 Dec 01 (1900 EST Sun 30 Dec 01)
T of 10-40 cm ground layer
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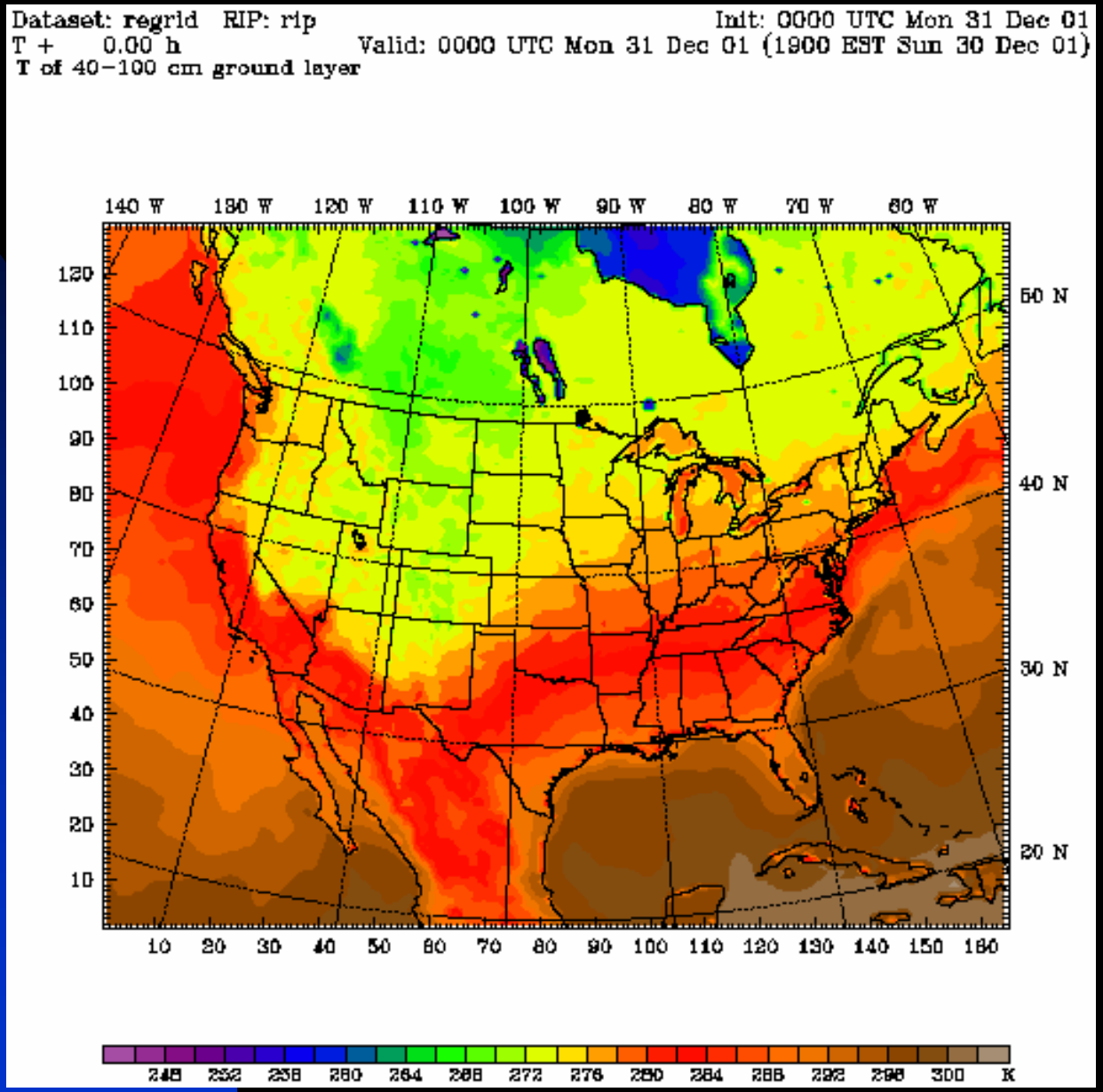
130 W
120 W
110 W
100 W
90 W
80 W
70 W
60 W
50 N
40 N
30 N
20 N
K


Dataset: regrid RIP: rip
Init: 0000 UTC Mon 31 Dec 01
T + 0.00 h
Valid: 0000 UTC Mon 31 Dec 01 (1900 EST Sun 30 Dec 01)
T of 40-100 cm ground layer
140 W
130 W
120 W
110 W
100 W
90 W
80 W
70 W
60 W
120
110
100
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80
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60
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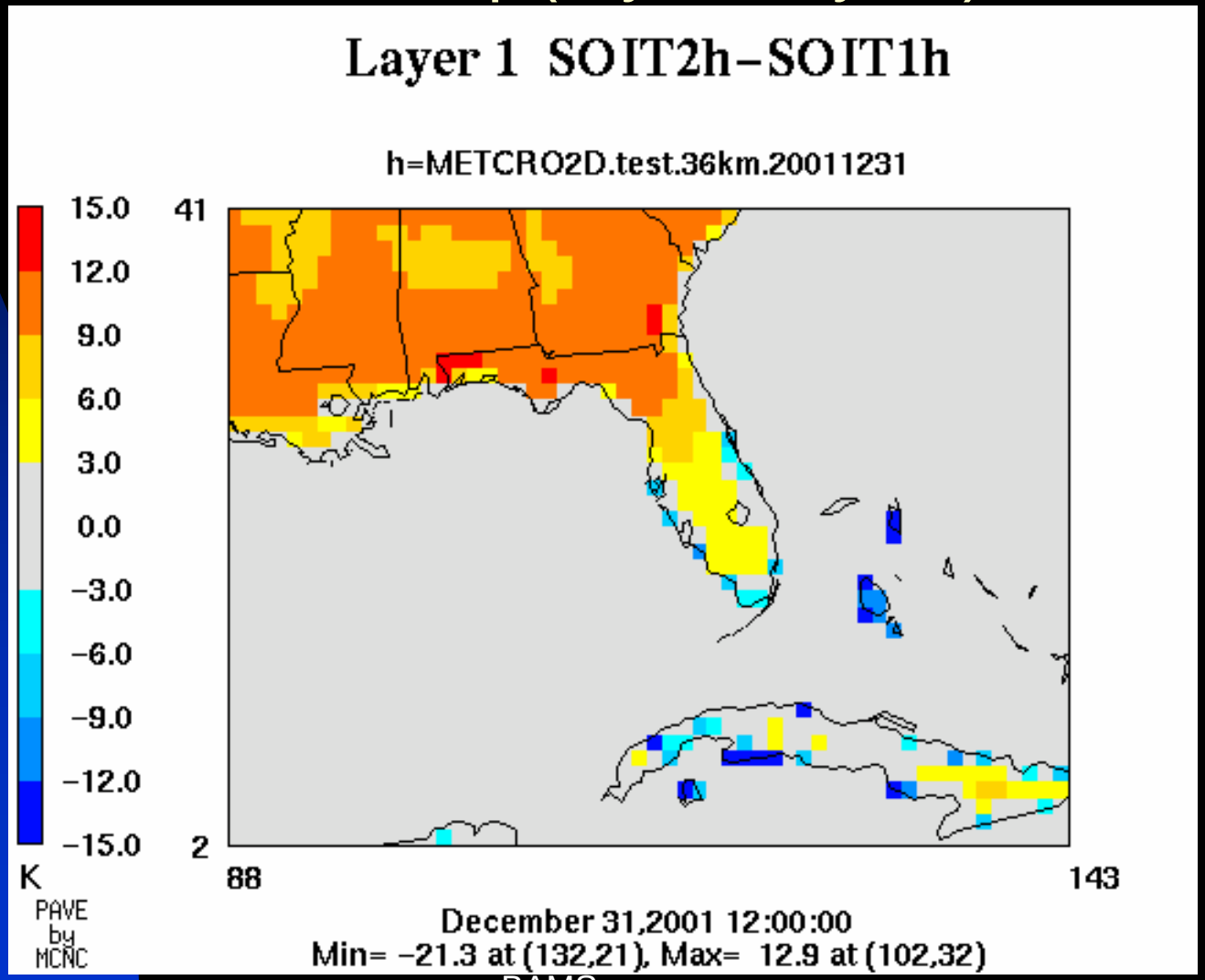
40
30
20
10
50 N
40 N
30 N
20 N
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
248 252 256 260 264 268 272 276 280 284 288 292 296 300 K

The Long and Winding Road (continued)

- Consulted Jon Pleim about my findings
  - P-X follows Blackadar approach for deep soil temperature initialization
  - Scheme developed before ETA fields were widely in use
  - Further testing recommended
- Explored using ETA soil temps directly
  - Decided to use 10-40 cm layer as a conservative test
    - Strangely ISMRD=2 initializes moisture from layer 4 (100-200cm)
  - Developed patch to take care of anomalously cold layer 2 temperatures
  - Temps increased 1-2K over eastern US

ETA Soil temp (Layer 2- layer 1)



The Long and Winding Road (continued)

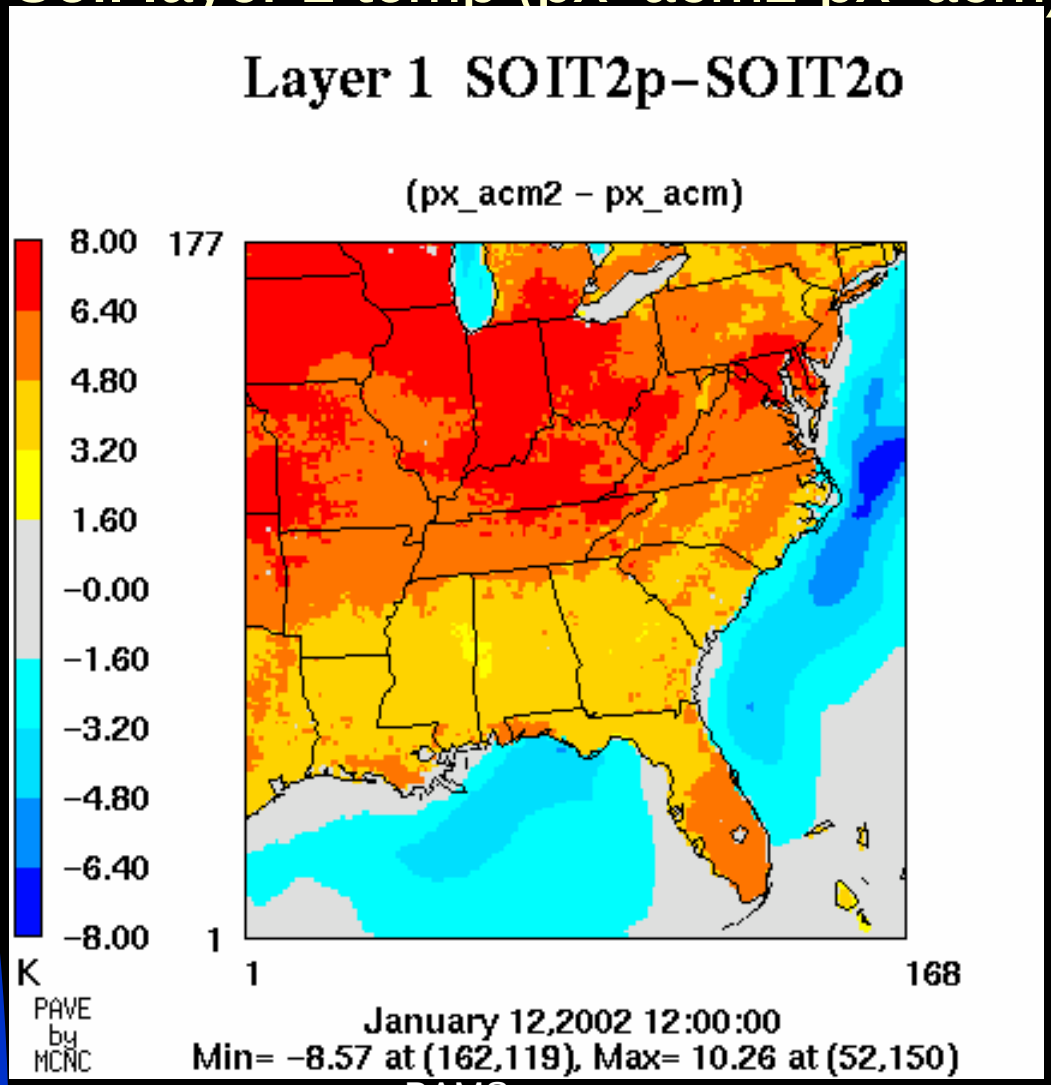
- Asked for Dec 31 input fields from EPA contractor for more direct comparisons
  - Found MMINPUTSM file!!
- EPA rerun was not cold-started, but rather initiated off of an Alpine run which cold-started on Dec 15
- Cold bias stems in large part from initialization during an extreme cold event
  - Jan 2-20 (VISTAS)
    - Avg obs: 279.49; 36 km bias: -1.67K
  - Dec 26 – Jan 2 (VISTAS)
    - Avg obs: 276.92; 36 km bias: -0.76K

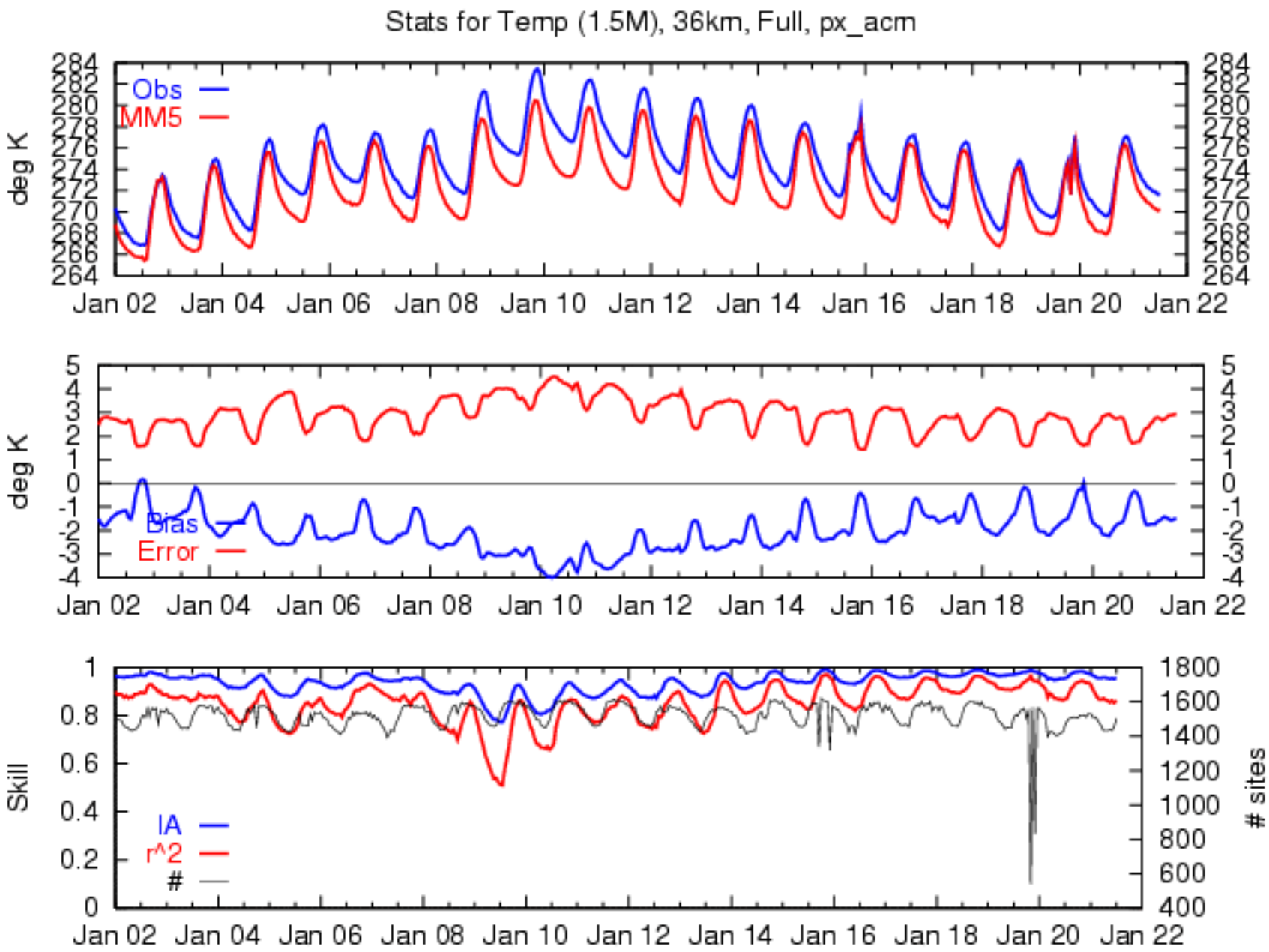
Results

- Ran MM5 with ISMRD=2 for each segment
  - Cold starts allow soil 2 temps to better represent actual temps encountered during segment
- Near-surface temp biases halved

VISTAS-36	ISMRD=1	ISMRD=2
T Bias:	-1.67 K	-0.78 K
T IA:	0.944	0.959
Spd IA:	0.775	0.786
QV IA:	0.976	0.976
RH IA:	0.801	0.812

Soil layer 2 temp (px_acm2-px_acm)

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Obs
MM5
deg K
284
282
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264
Jan 02
Jan 04
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Jan 20
Jan 22
Bias
Error
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Skill
IA
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1400
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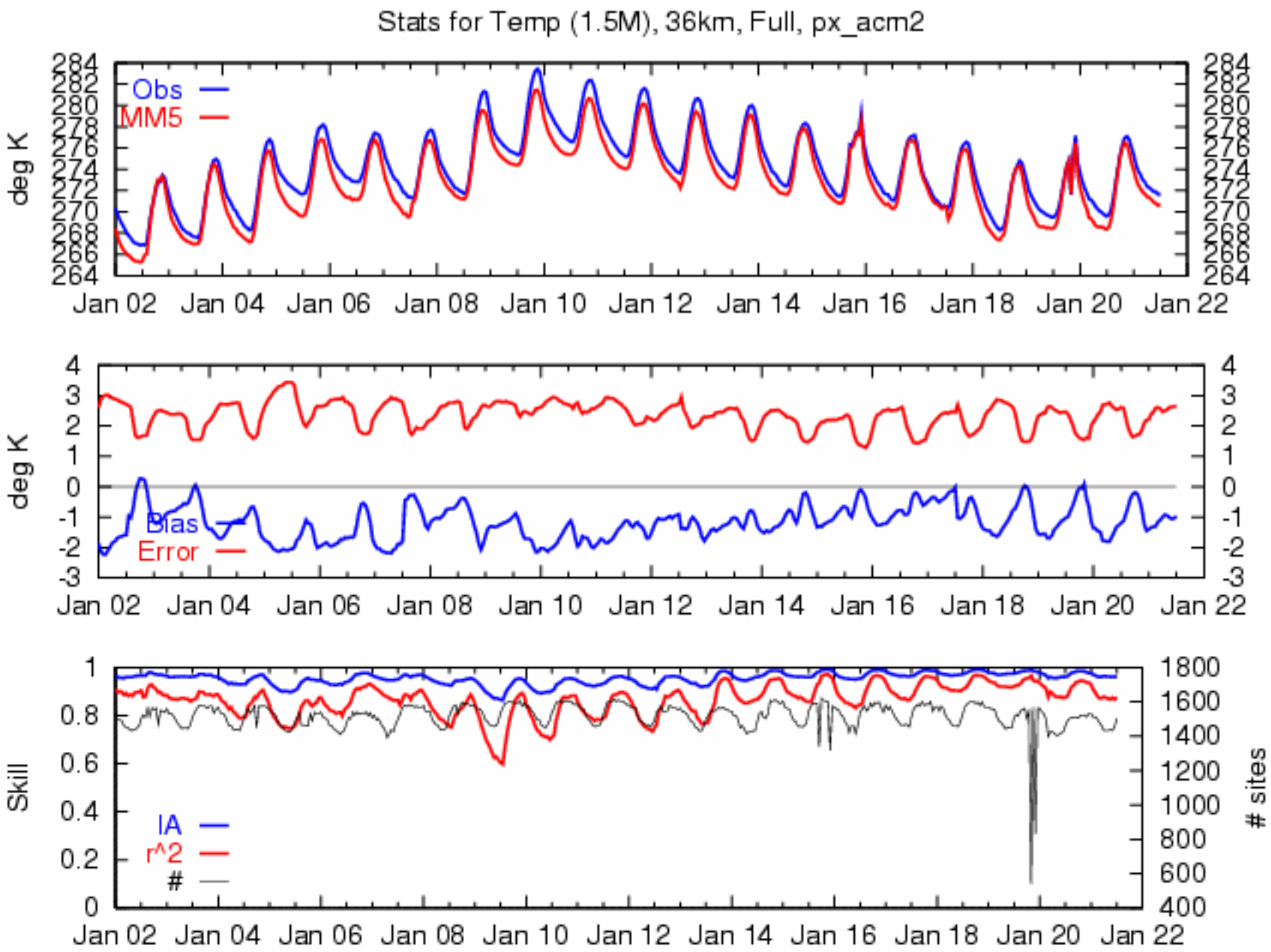
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deg K
Bias
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Skill
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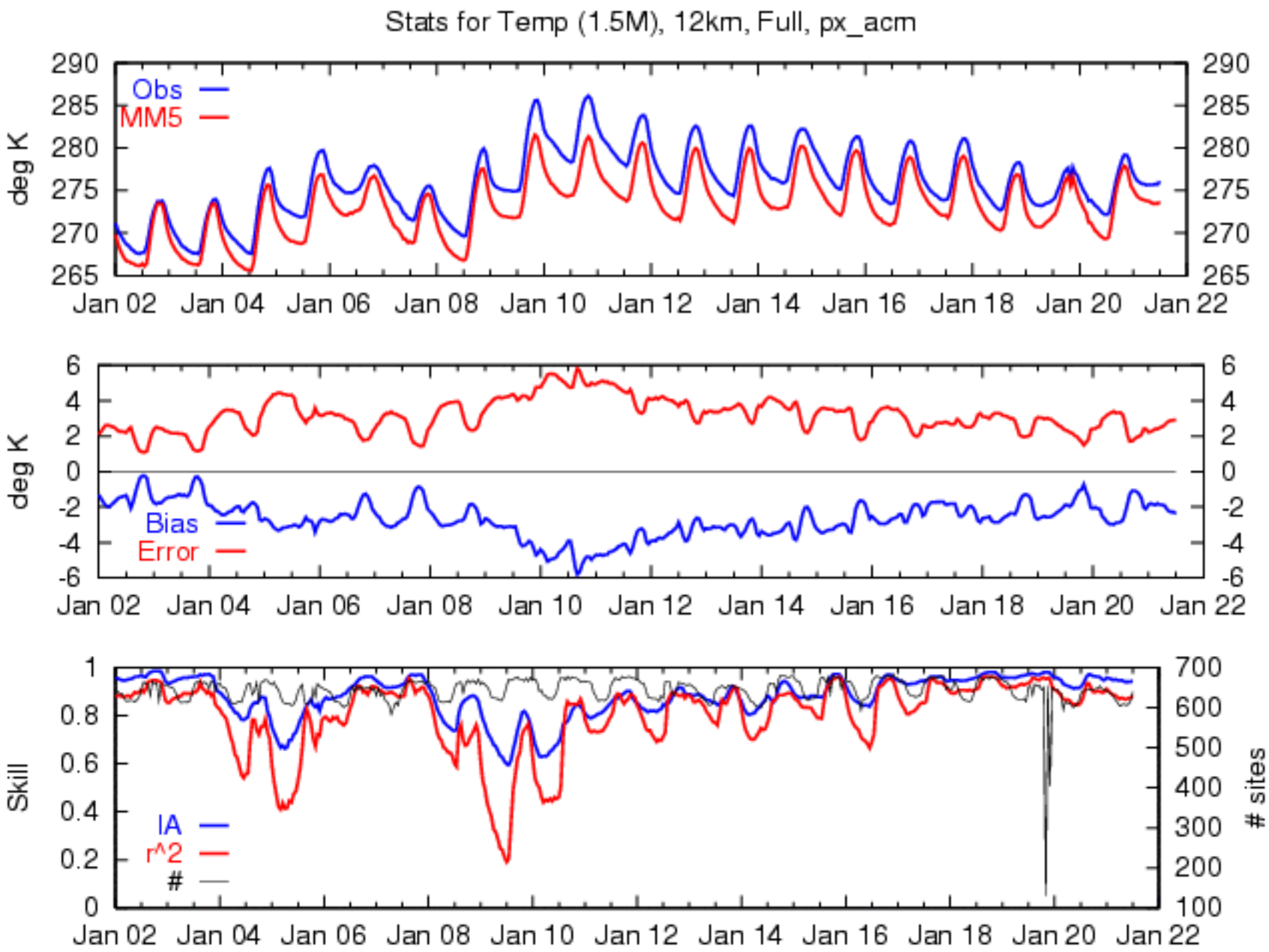
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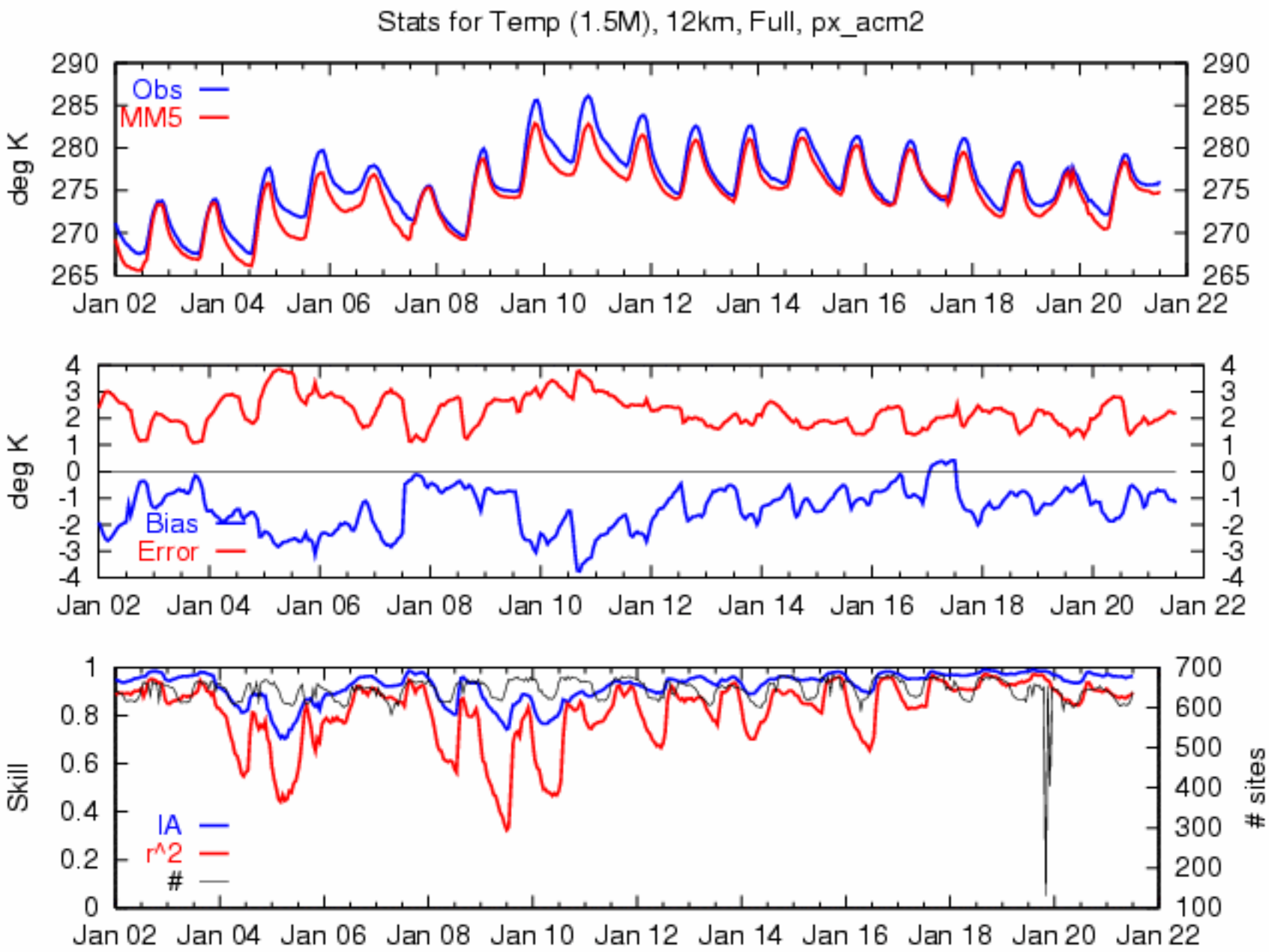
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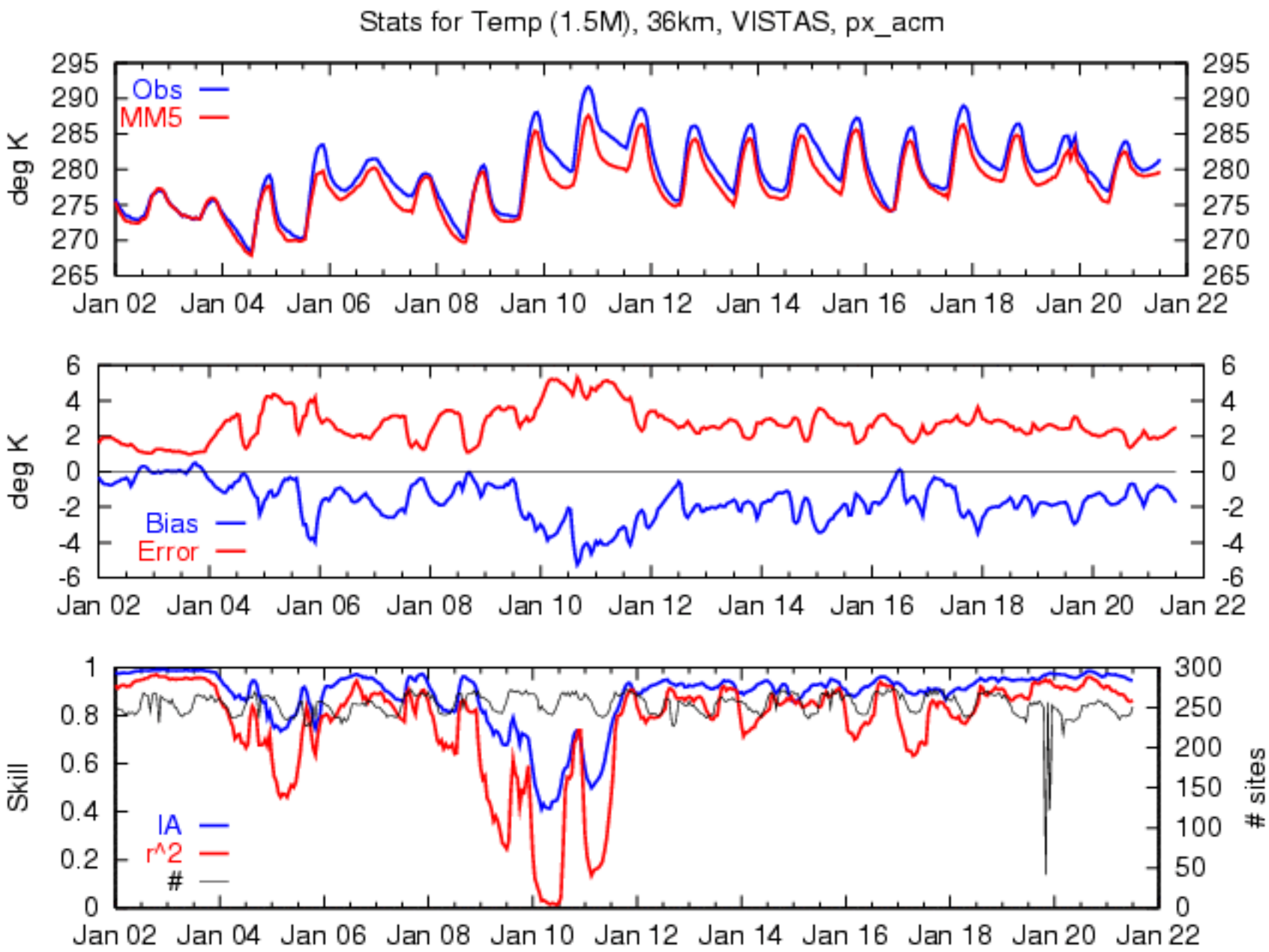
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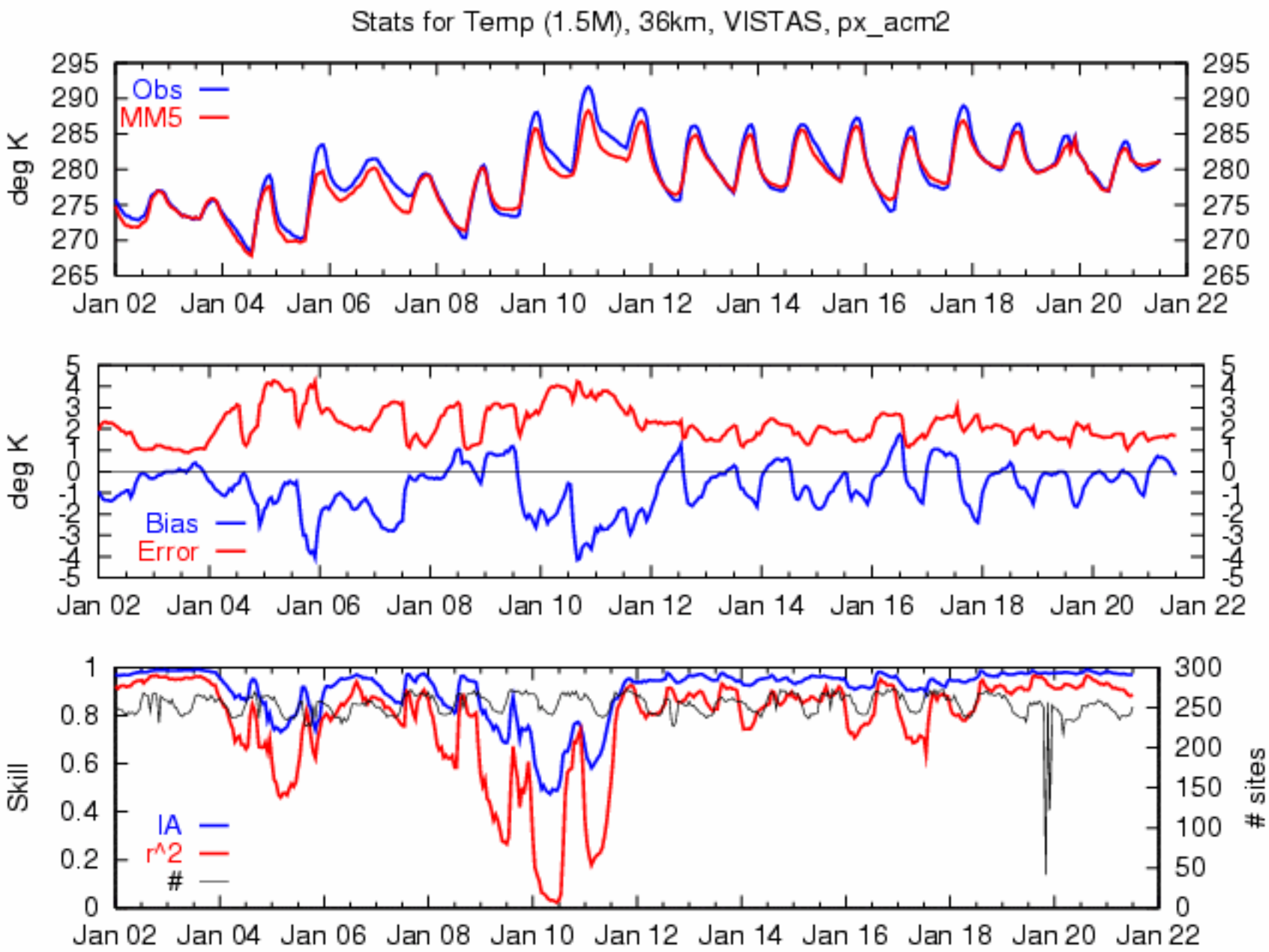
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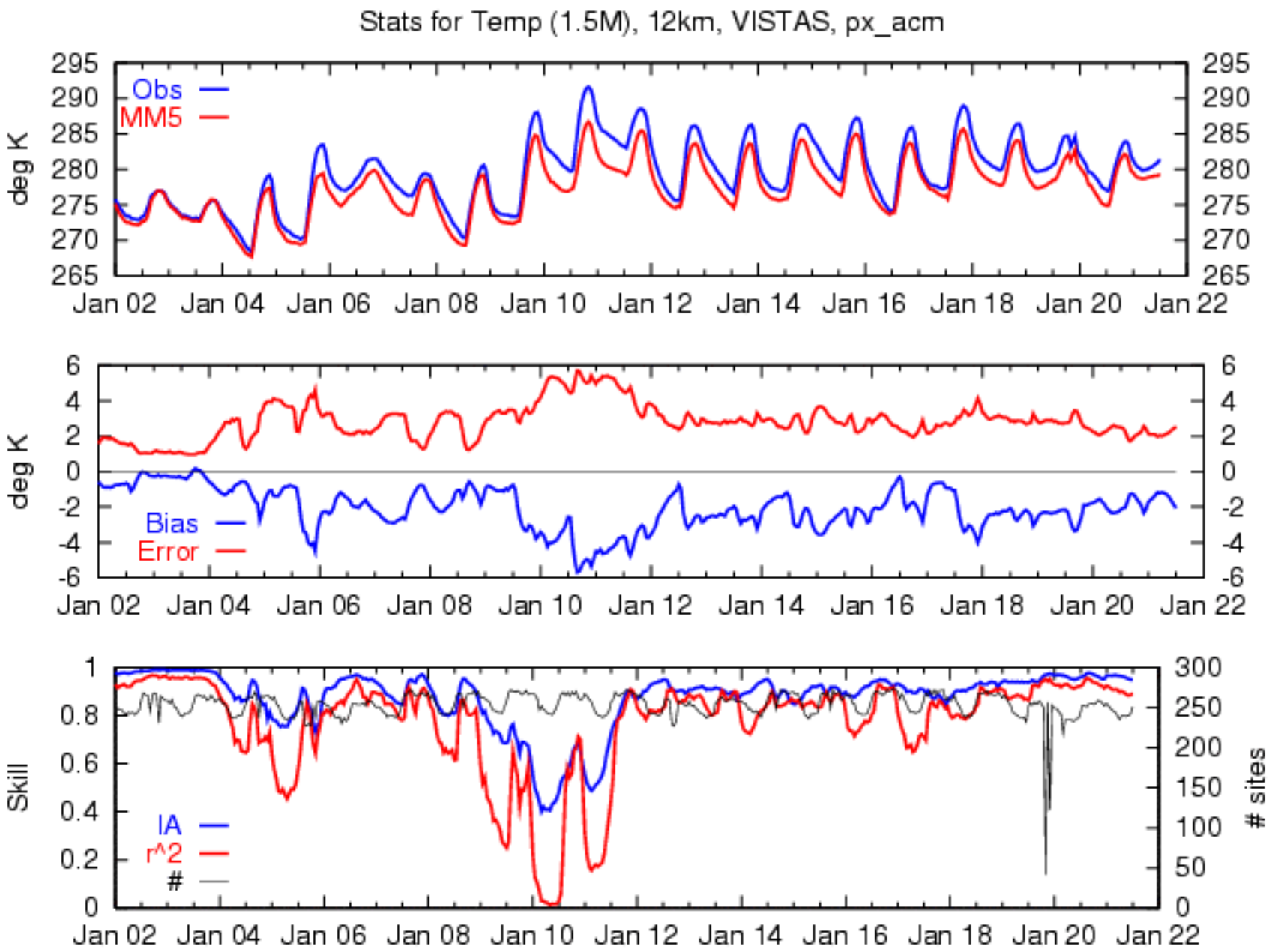
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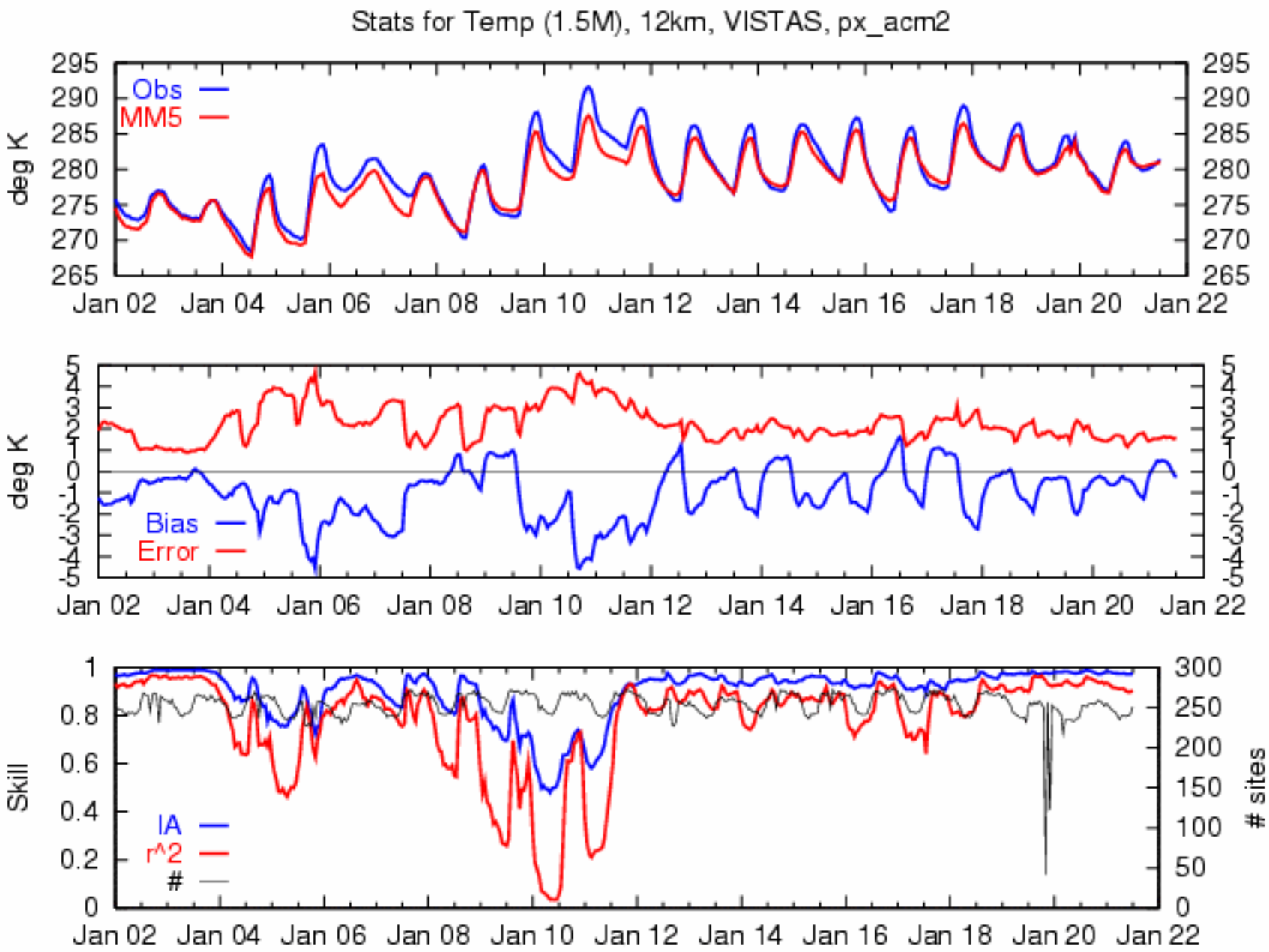
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sites
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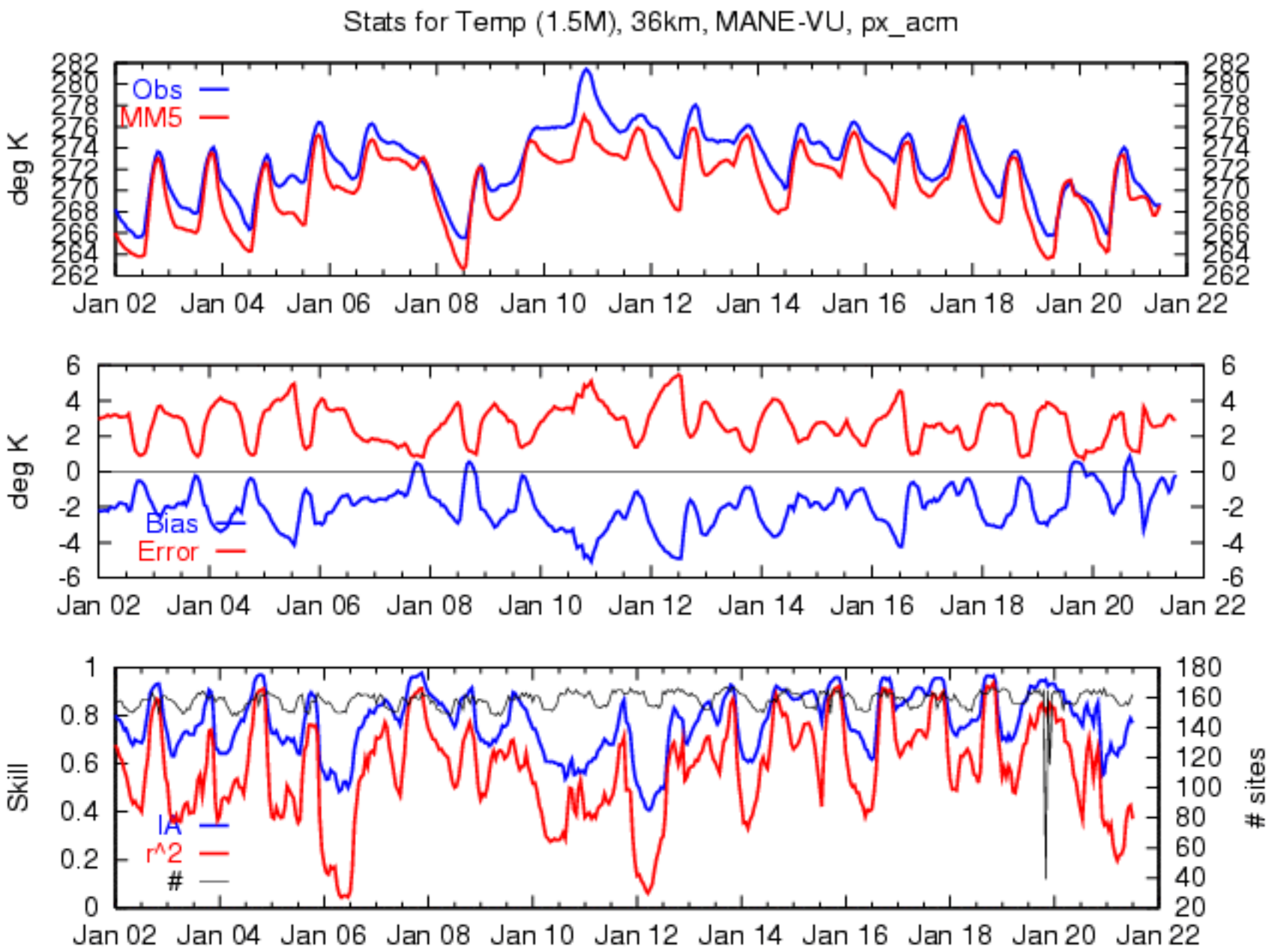
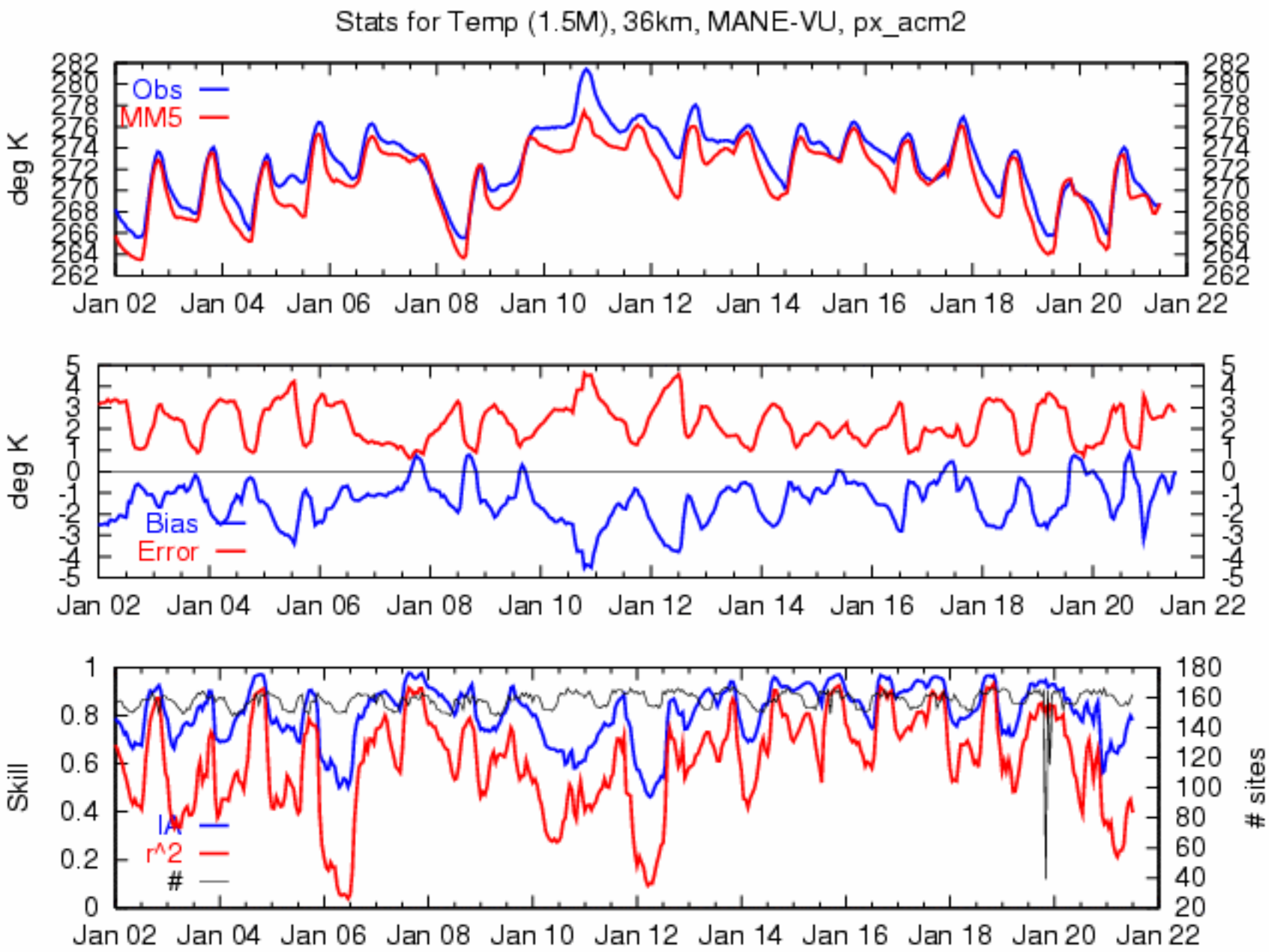
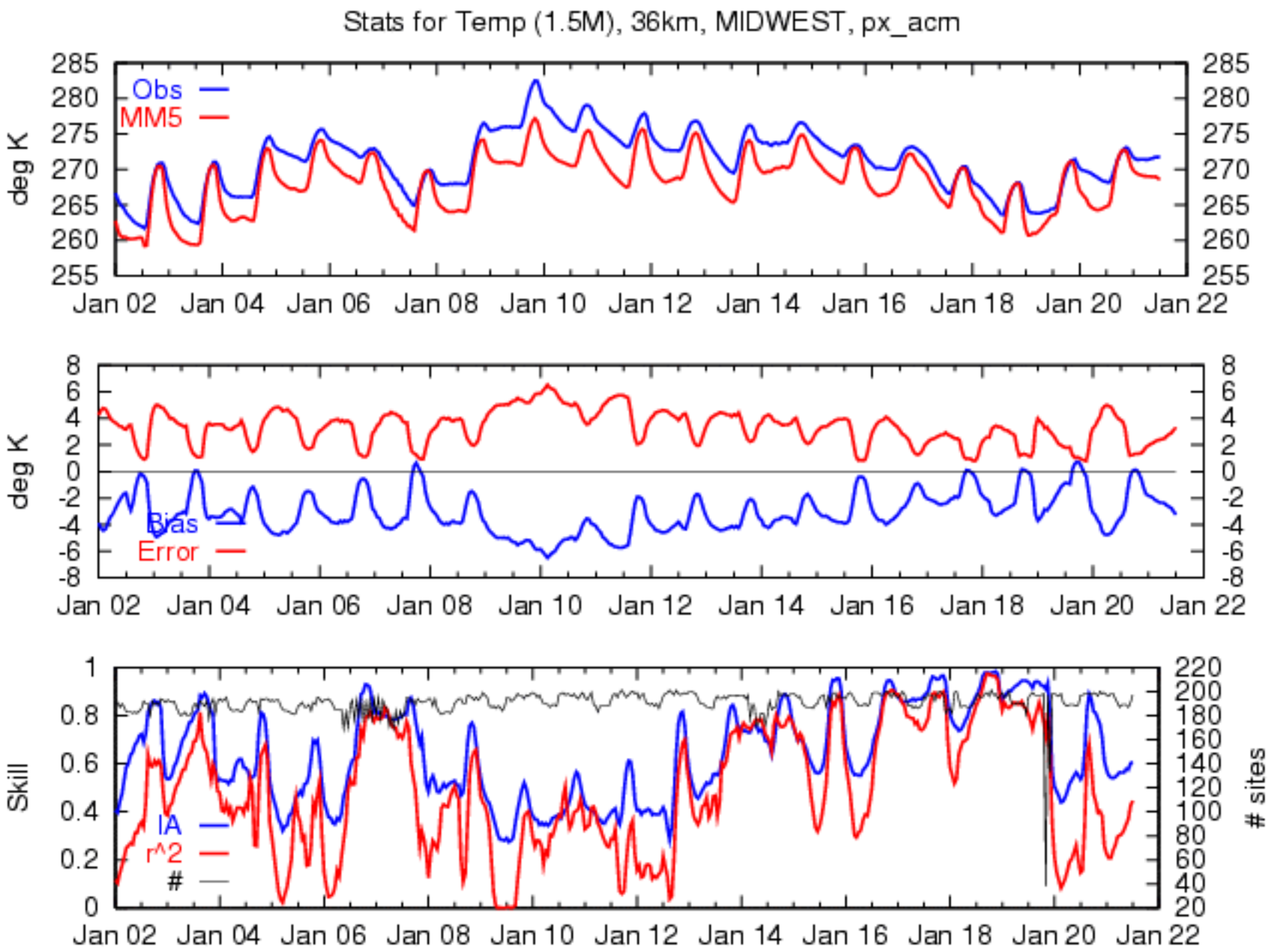
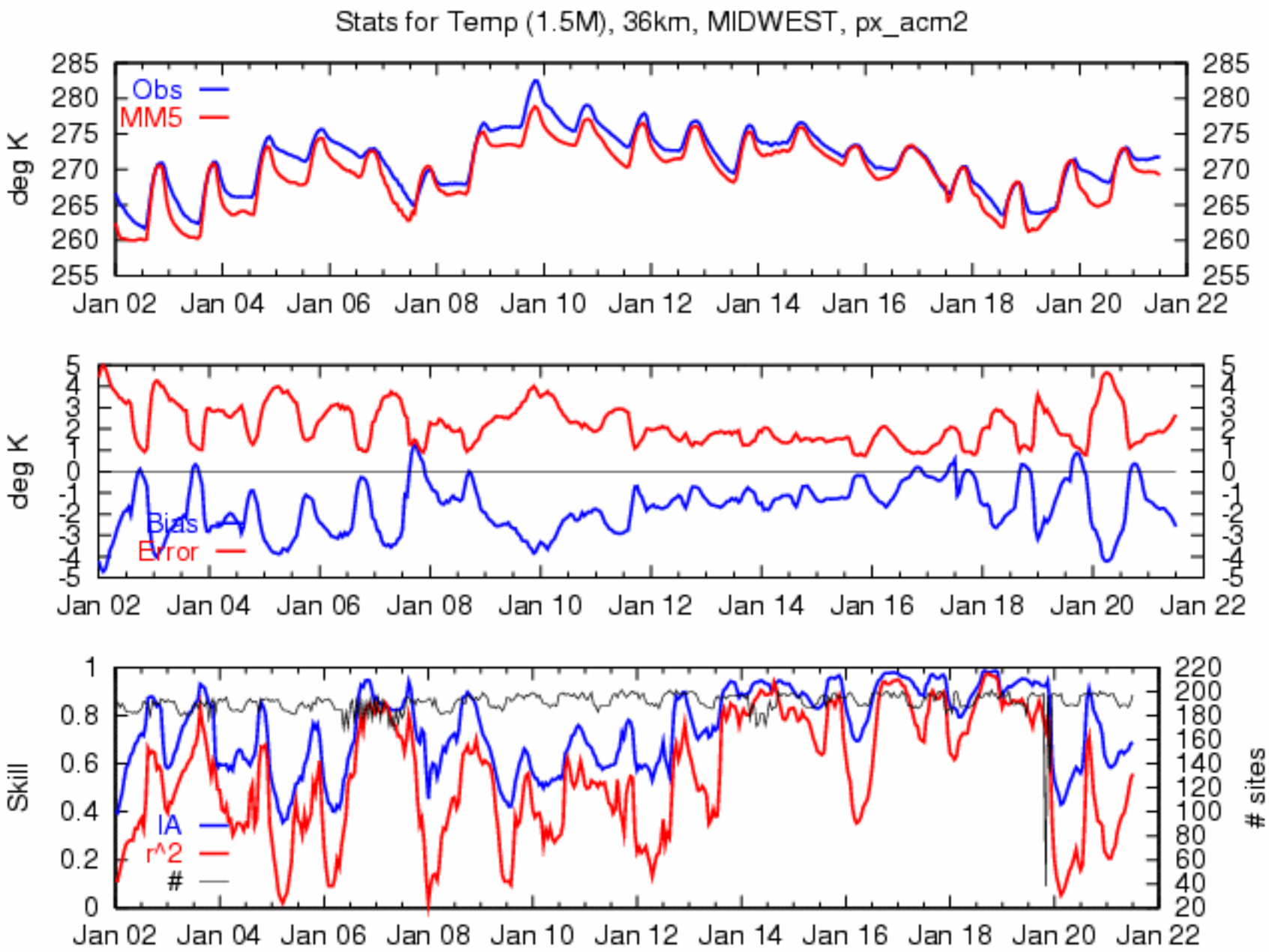
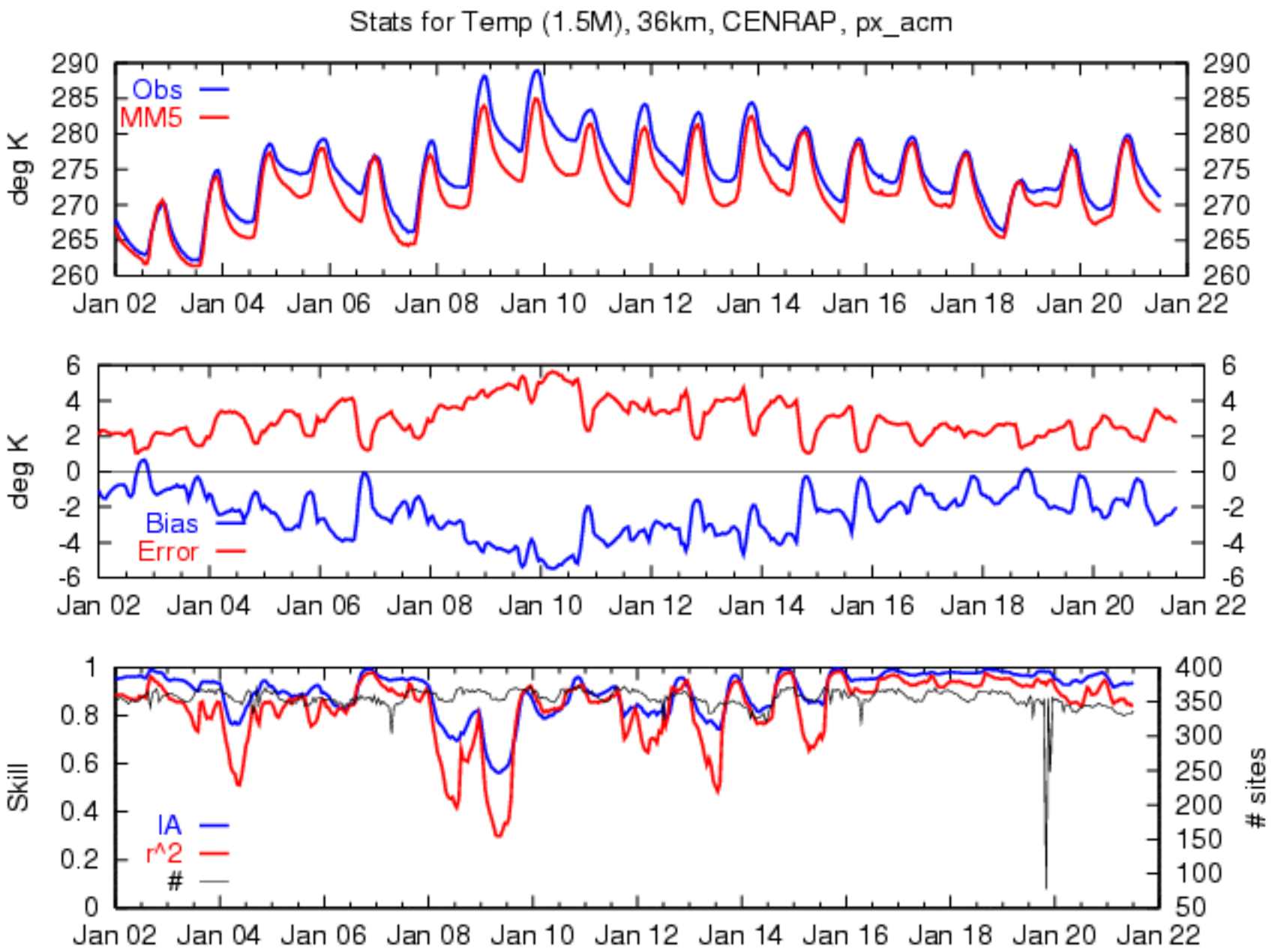
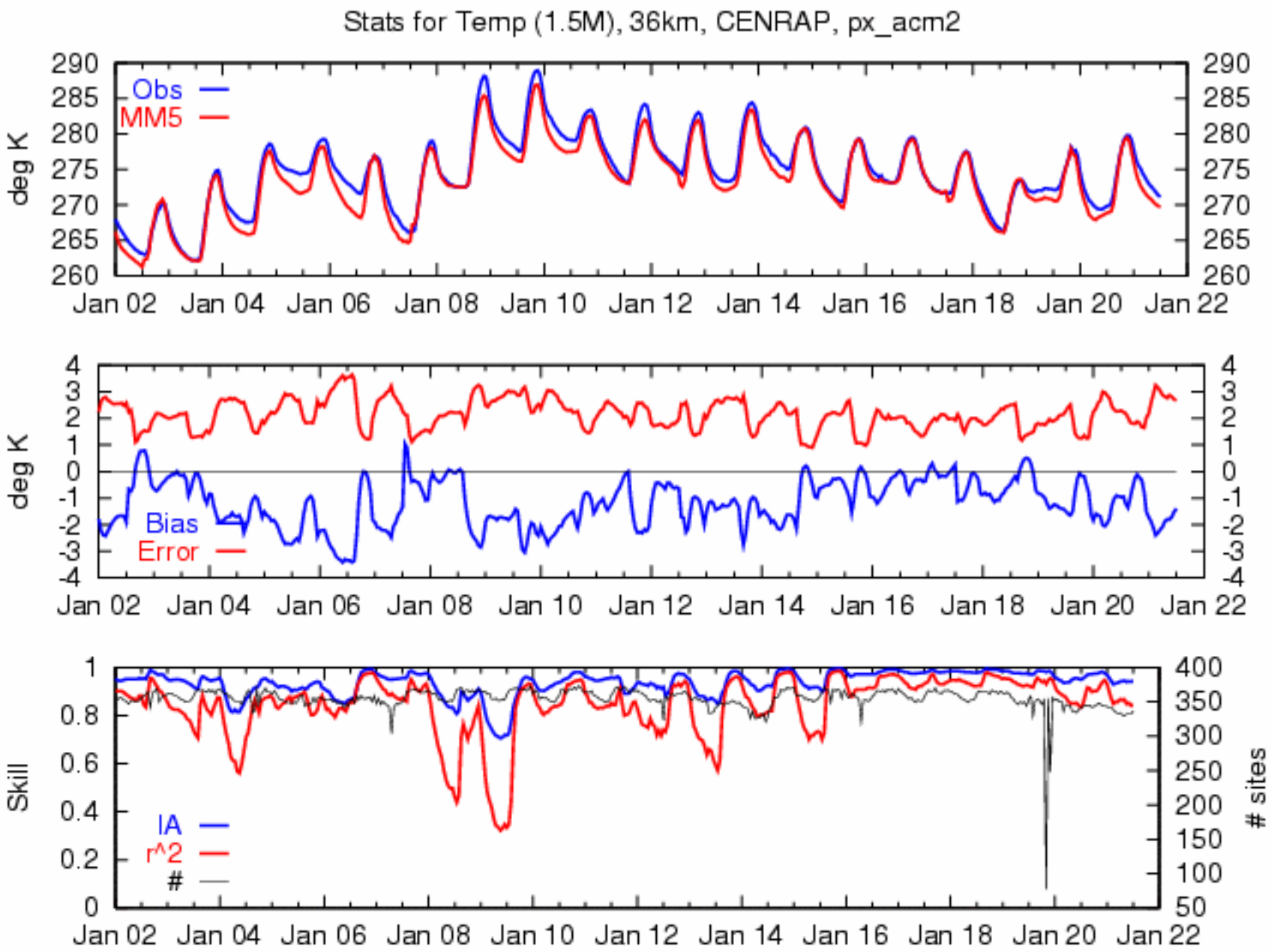

Stats for Temp (1.5M), 36km, MANE-VU, px_acm
deg K
Obs
MM5
282
280
278
276
274
272
270
268
266
264
262
Jan 02
Jan 04
Jan 06
Jan 08
Jan 10
Jan 12
Jan 14
Jan 16
Jan 18
Jan 20
Jan 22
deg K
Bias
Error
6
4
2
0
-2
-4
-6
Skill
IA
r^2
#
1
0.8
0.6
0.4
0.2
0
sites
180
160
140
120
100
80
60
40
20

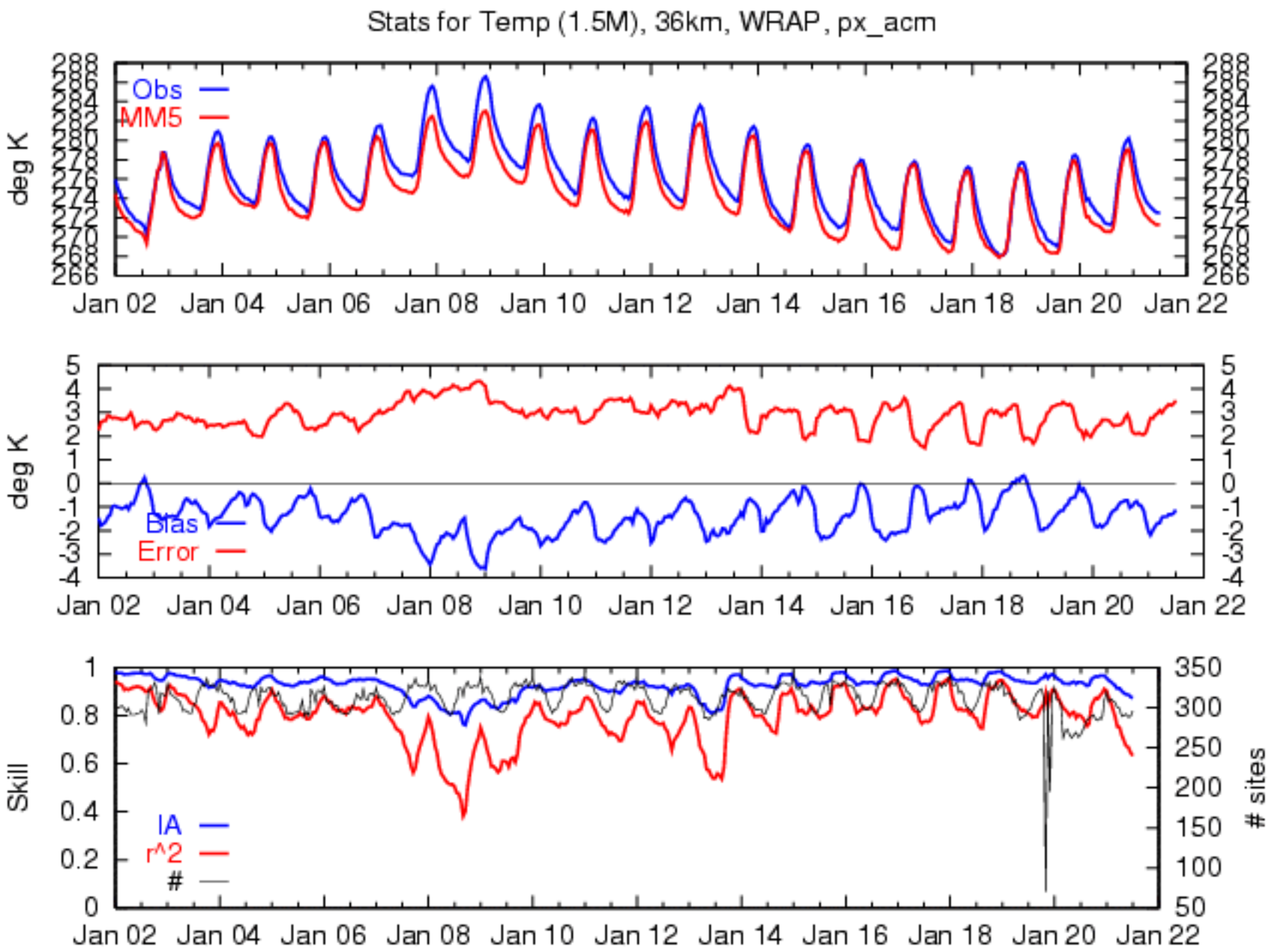

Stats for Temp (1.5M), 36km, MANE-VU, px_acm2
deg K
Obs
MM5
282
280
278
276
274
272
270
268
266
264
262
Jan 02
Jan 04
Jan 06
Jan 08
Jan 10
Jan 12
Jan 14
Jan 16
Jan 18
Jan 20
Jan 22
deg K
Bias
Error
5
4
3
2
1
0
-1
-2
-3
-4
-5
Skill
IA
r^2
#
1
0.8
0.6
0.4
0.2
0
sites
180
160
140
120
100
80
60
40
20

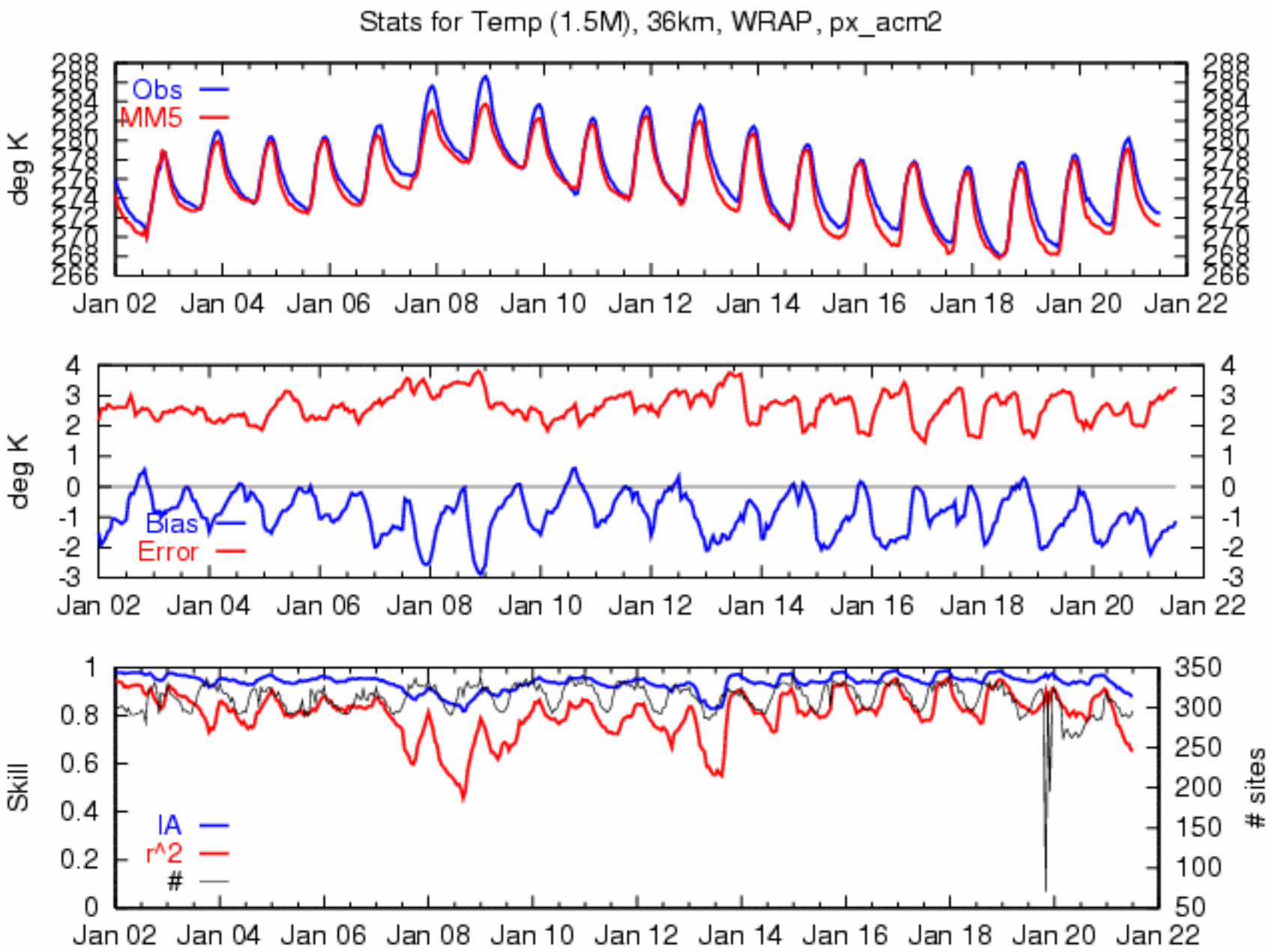

Stats for Temp (1.5M), 36km, MIDWEST, px_acm
deg K
Obs
MM5
285
280
275
270
265
260
255
Jan 02
Jan 04
Jan 06
Jan 08
Jan 10
Jan 12
Jan 14
Jan 16
Jan 18
Jan 20
Jan 22
deg K
Bias
Error
8
6
4
2
0
-2
-4
-6
-8
Skill
IA
r^2
#
1
0.8
0.6
0.4
0.2
0
sites
220
200
180
160
140
120
100
80
60
40
20


Stats for Temp (1.5M), 36km, MIDWEST, px_acm2
deg K
Obs
MM5
285
280
275
270
265
260
255
Jan 02
Jan 04
Jan 06
Jan 08
Jan 10
Jan 12
Jan 14
Jan 16
Jan 18
Jan 20
Jan 22
deg K
Bias
Error
5
4
3
2
1
0
-1
-2
-3
-4
-5
Skill
IA
r^2
#
1
0.8
0.6
0.4
0.2
0
sites
220
200
180
160
140
120
100
80
60
40
20


Stats for Temp (1.5M), 36km, CENRAP, px_acm
deg K
Obs
MM5
290
285
280
275
270
265
260
Jan 02
Jan 04
Jan 06
Jan 08
Jan 10
Jan 12
Jan 14
Jan 16
Jan 18
Jan 20
Jan 22
deg K
Bias
Error
6
4
2
0
-2
-4
-6
Skill
IA
r^2
#
1
0.8
0.6
0.4
0.2
0
sites
400
350
300
250
200
150
100
50


Stats for Temp (1.5M), 36km, CENRAP, px_acm2
deg K
Obs
MM5
290
285
280
275
270
265
260
Jan 02
Jan 04
Jan 06
Jan 08
Jan 10
Jan 12
Jan 14
Jan 16
Jan 18
Jan 20
Jan 22
deg K
Bias
Error
4
3
2
1
0
-1
-2
-3
-4
Skill
IA
r^2
#
1
0.8
0.6
0.4
0.2
0
sites
400
350
300
250
200
150
100
50


Stats for Temp (1.5M), 36km, WRAP, px_acm
Obs
MM5
deg K
Jan 02
Jan 04
Jan 06
Jan 08
Jan 10
Jan 12
Jan 14
Jan 16
Jan 18
Jan 20
Jan 22
Bias
Error
Skill
IA
r^2
#
sites


Stats for Temp (1.5M), 36km, WRAP, px_acm2
deg K
Obs
MM5
Jan 02
Jan 04
Jan 06
Jan 08
Jan 10
Jan 12
Jan 14
Jan 16
Jan 18
Jan 20
Jan 22
deg K
Bias
Error
Skill
IA
r^2
#
sites

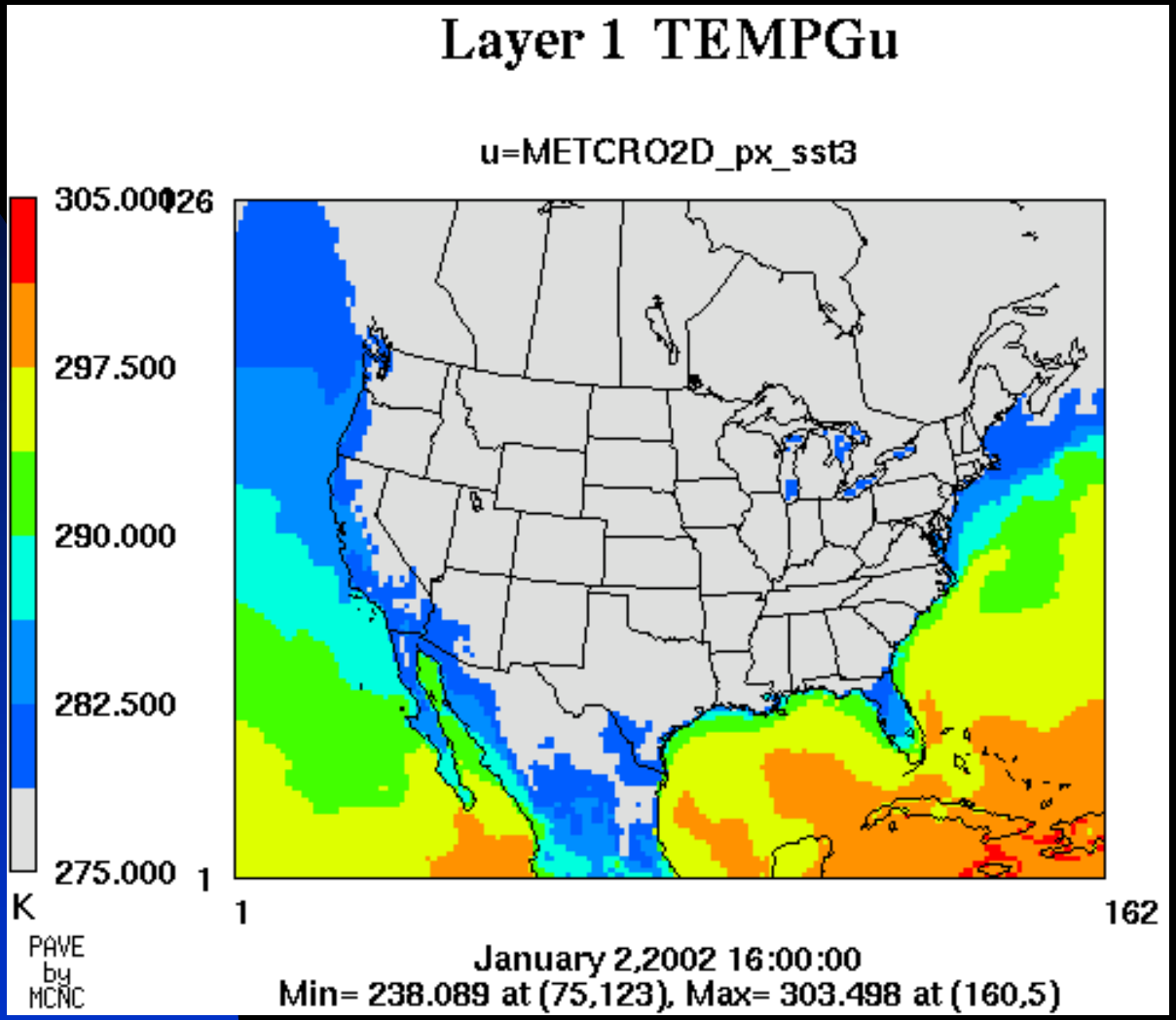
Results (continued)

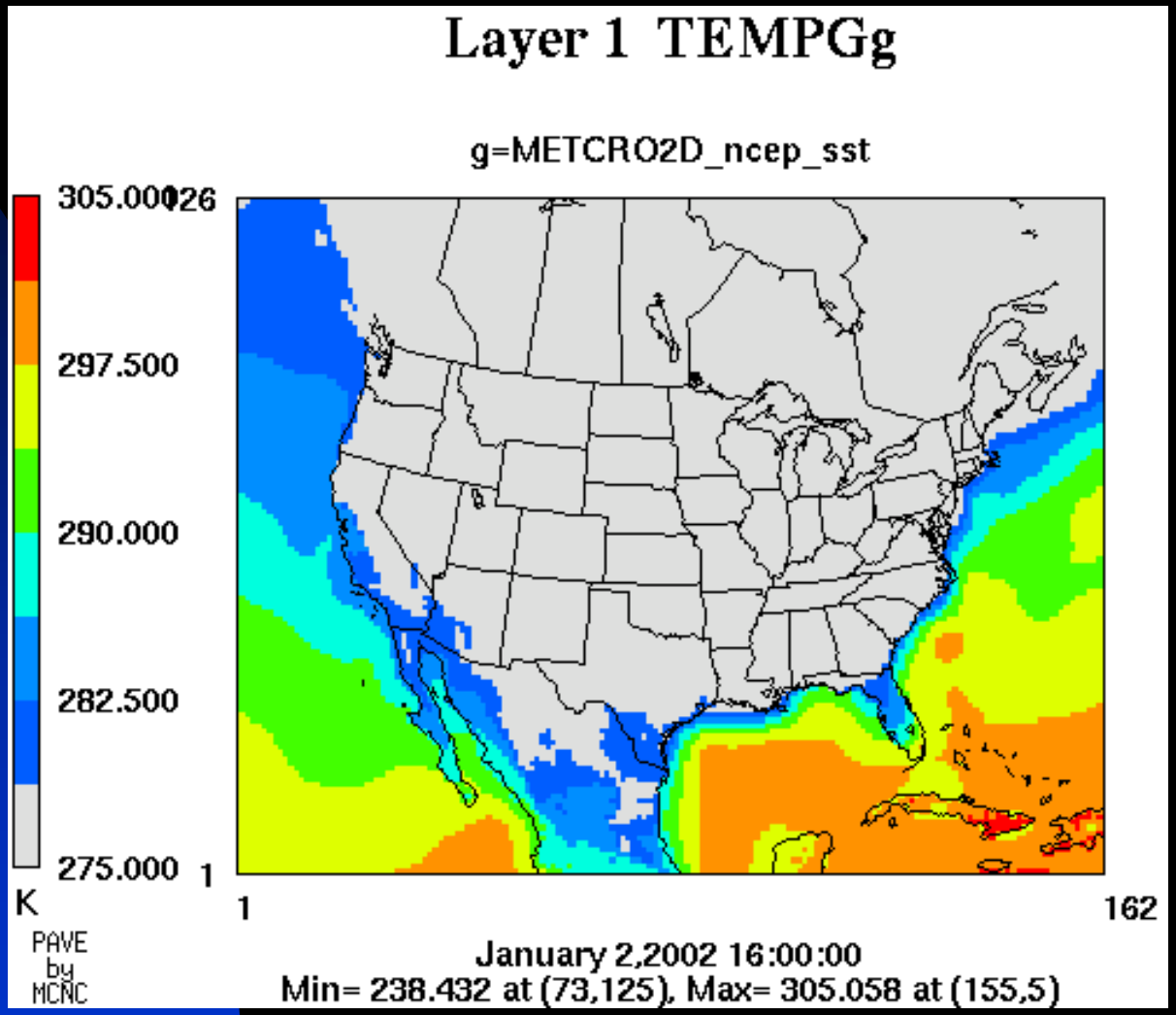
- VISTAS web site
  - http://www.emc.mcnc.org/projects/VISTAS/vistas.html
  - Model Results: Evaluation Products
    - README (updated Jun 19, 2003)
    - Spatial Products
    - Spatial Aloft Products
    - Timeseries Products
    - Sounding Products
    - Spatial Statistics Products
    - Timeseries Statistics Products
    - Combination Products
    - Timeseries Statistics Aloft Products
    - Statistical Tables Form
    - Profiler Products (under development)

Results (Continued)

- Timings (Wall clock, 5.5 day run)

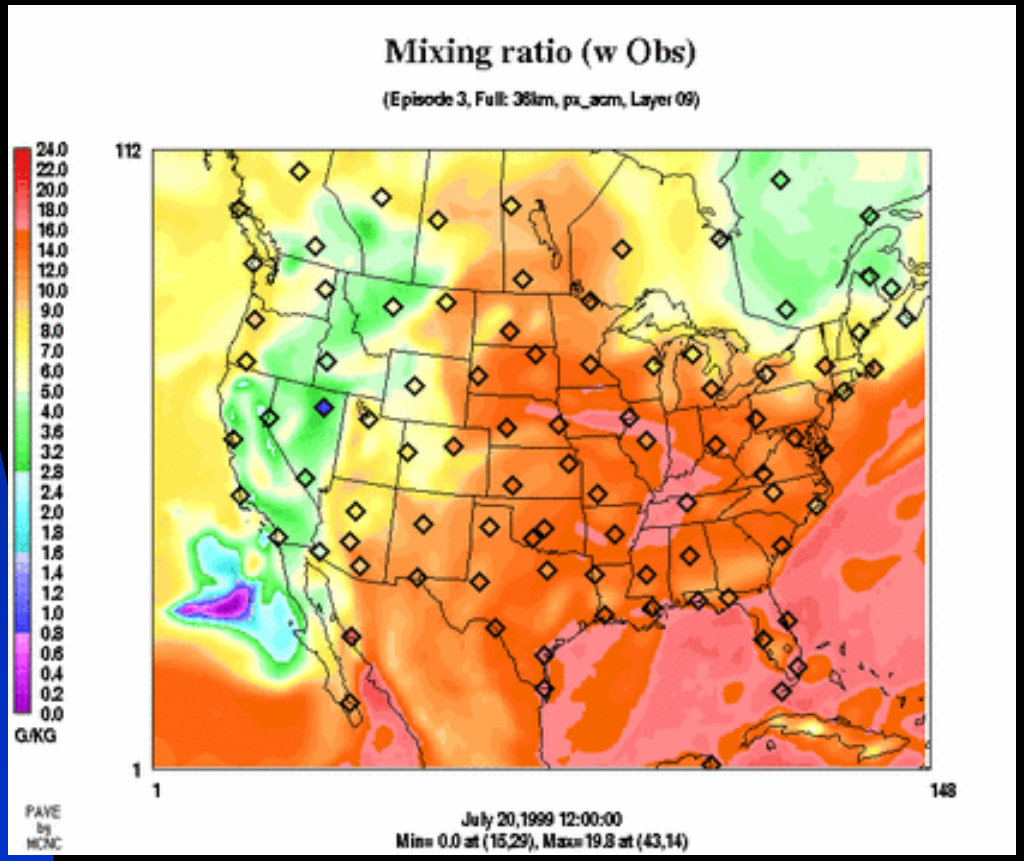
px_acm	19.48 hr
noah_mrf	16.16
multi_blkdr	19.55
moah_eta-my	16.68


Layer 1 TEMPGu
u=METCRO2D_px_sst3
305.00026
297.500
290.000
282.500
275.000
K
1
1
162
PAVE
by
MCNC
January 2,2002 16:00:00
Min= 238.089 at (75,123), Max= 303.498 at (160,5)

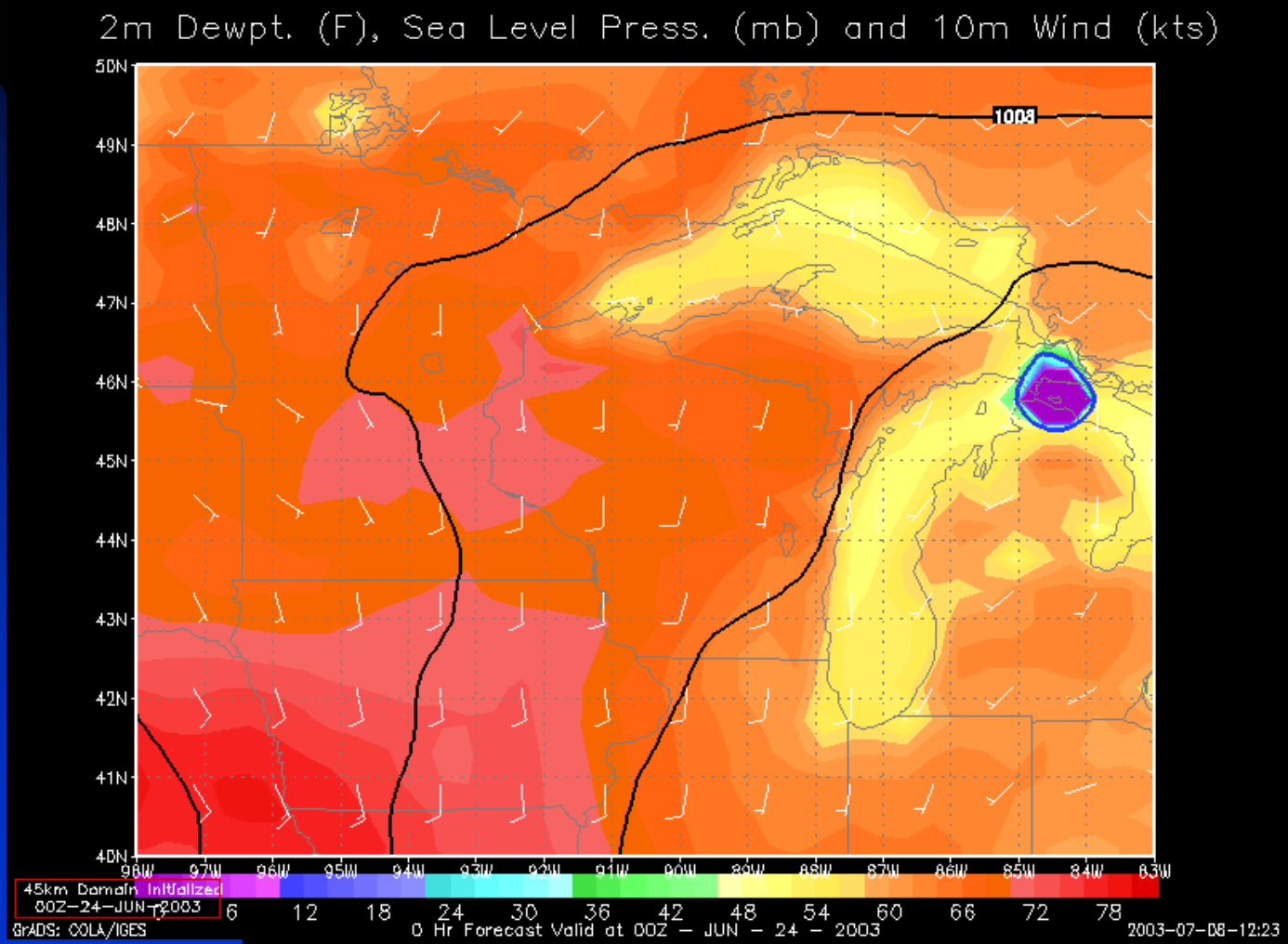

Layer 1 TEMPGg
g=METCRO2D_ncep_sst
305.00026
297.500
290.000
282.500
275.000
K
1
1
162
PAVE
by
MCNC
January 2,2002 16:00:00
Min= 238.432 at (73,125), Max= 305.058 at (155,5)

Results (continued)

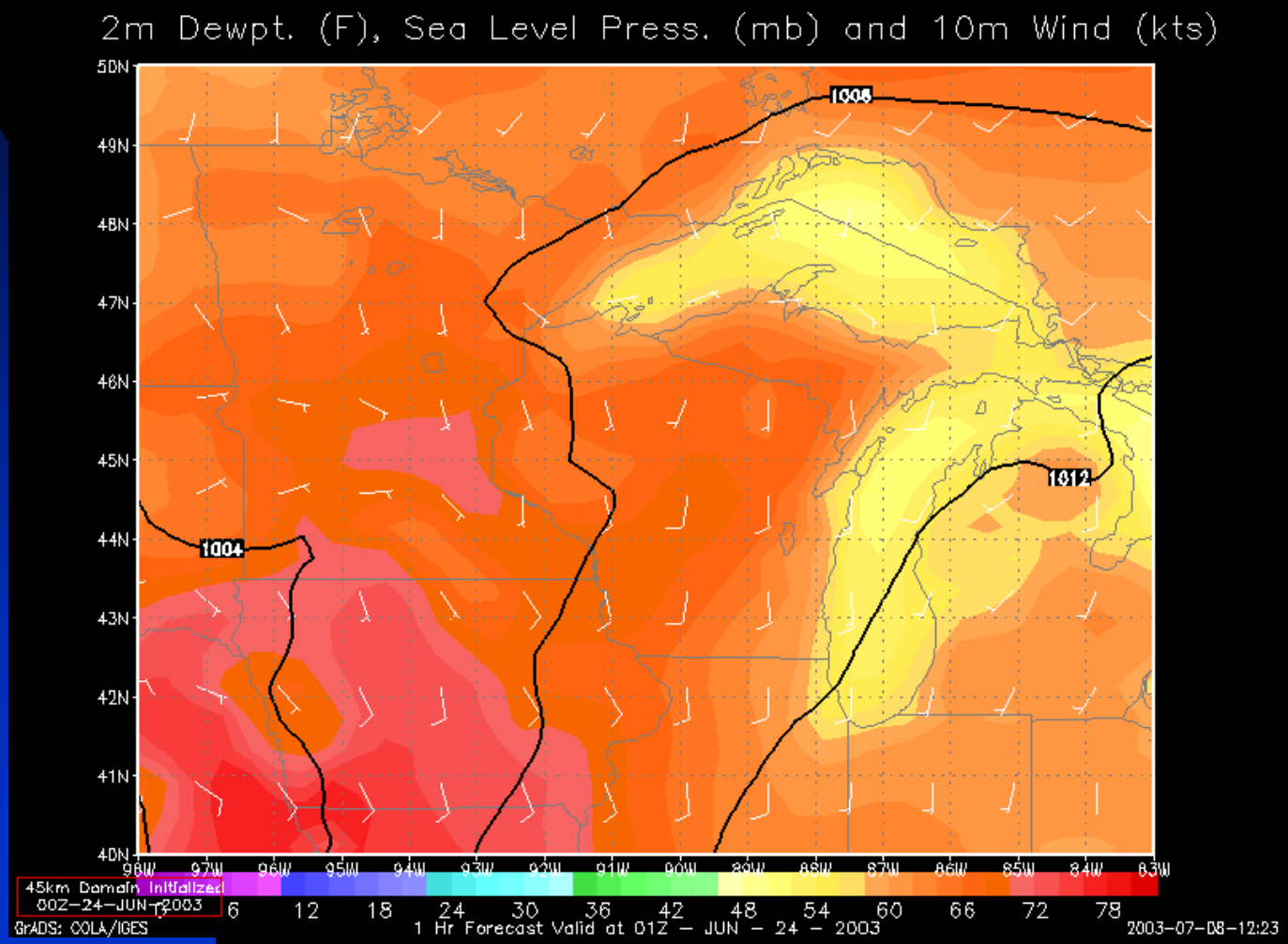
- Moisture “holes”



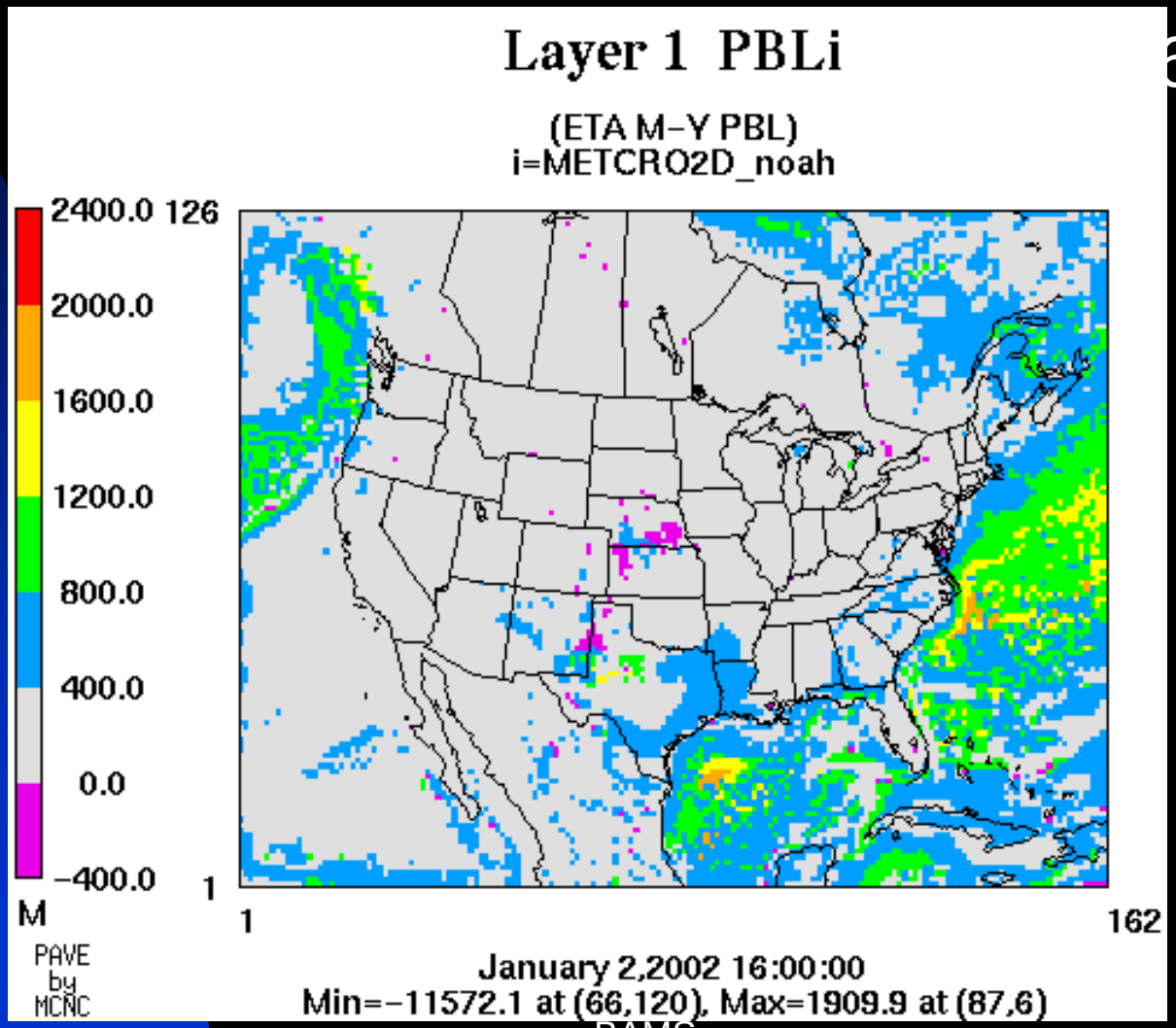
Results (continued)



Results (continued)



Results (continued)



6.0

Conclusions

- P-X temperatures affected strongly by initialization
- Watch out for moisture “holes”
  - Perhaps use RAWINS/LITTLE_R as INTERPF input
- P-X results generally good for all sensitivities
- More results soon to be posted on web site