MM5 to CMAQ Layer Collapsing & Application of MCIPv1 vs. MCIPv2

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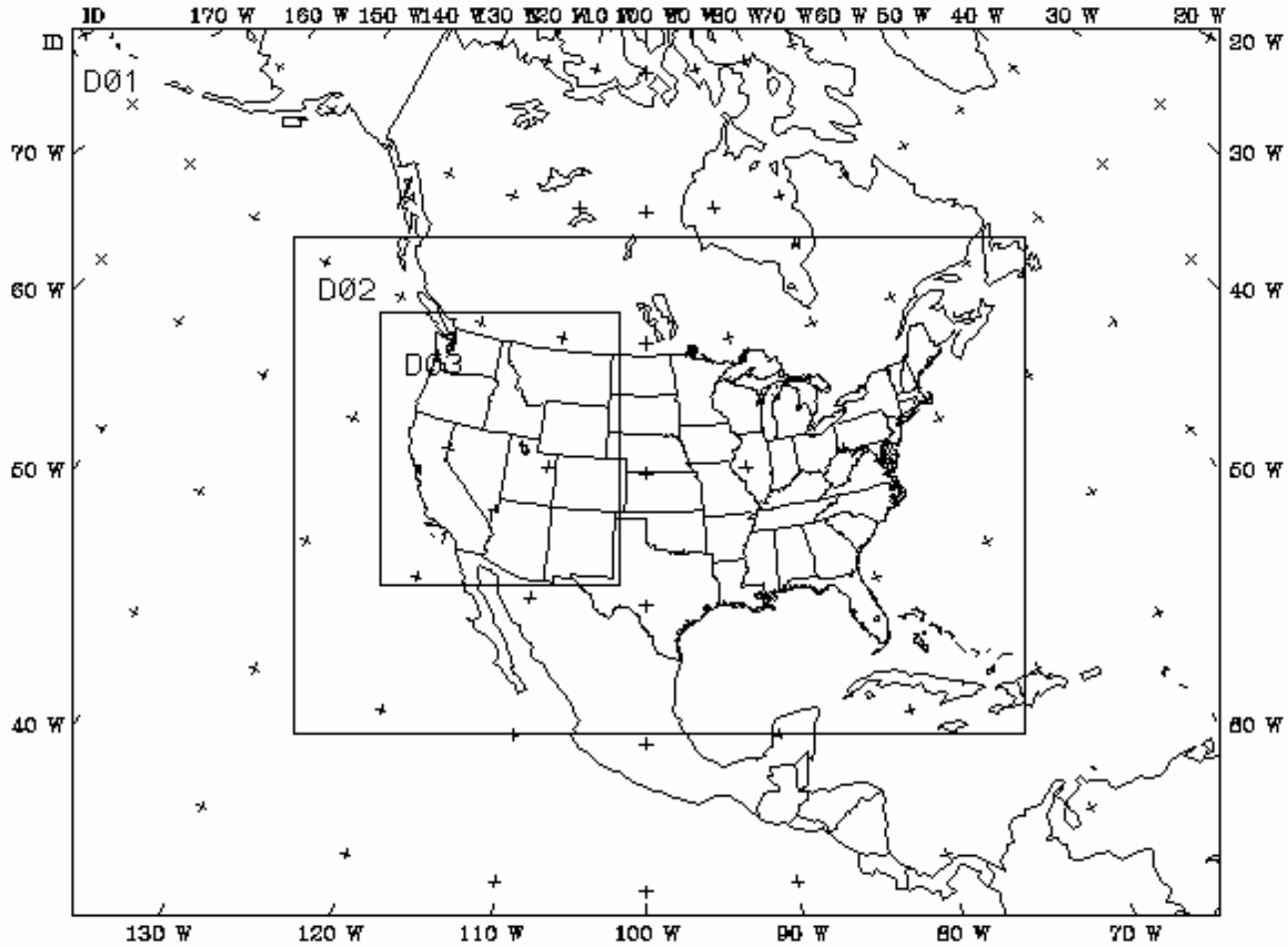
Outline

- Layer Collapsing
  - The need of layer collapsing
  - Results of layer collapsing
- MCIP v.1 vs. MCIP v.2
  - Model comparison
- Summary

MM5 Modeling Domain



MM5 Physics Options

- One-way nested grids
- Nonhydrostatic dynamics
- Four-dimensional data assimilation (FDDA):
- Analysis nudging of wind, temperature, and mixing ratios
- Explicit moisture treatment:
- 3-D predictions of cloud and precipitation fields
- Simple ice microphysics
- Cloud effects on surface radiation
- Anthes-Kuo (108-km grid)
- Kain-Fritsch (36-km grid)
- No shallow convection
- …….

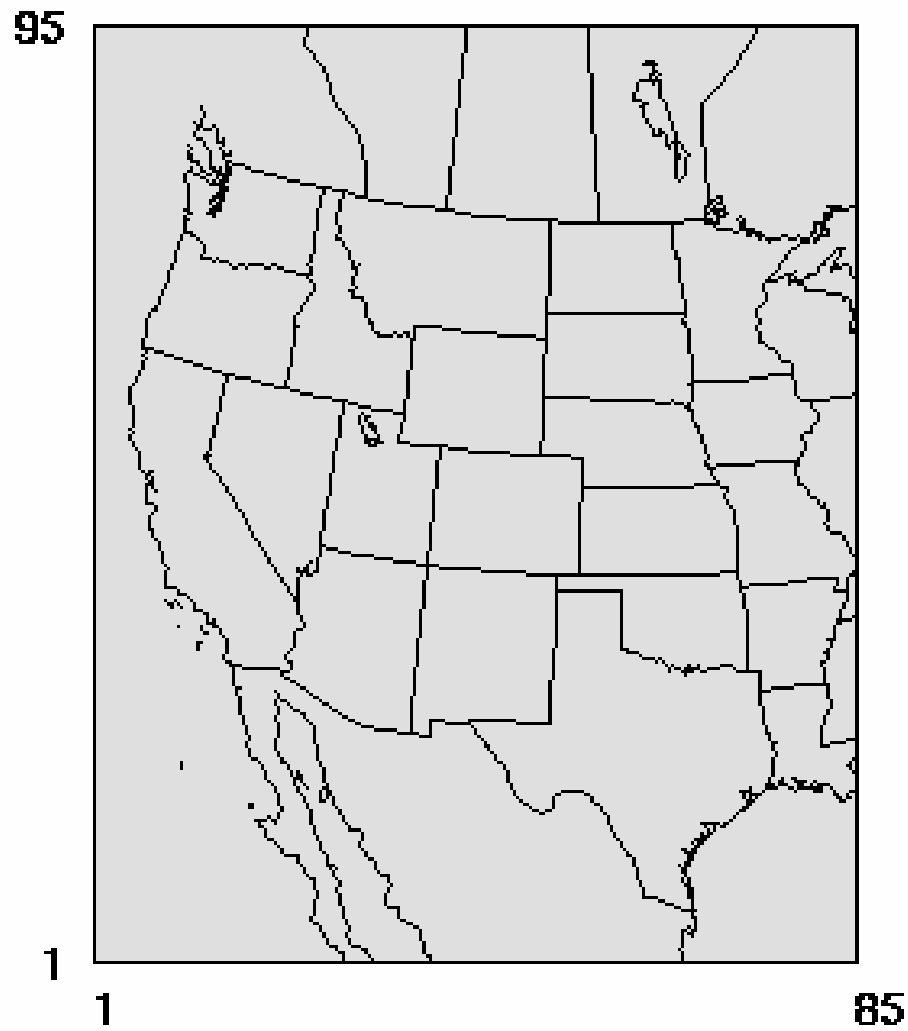
(from Olerud, et al., "Meteorological Modeling of 1996 for the United States with MM5, September 29, 2000", MCNC.)

MM5 Vertical Structure

Level	Sigma	Height (m)	Pressure (mb)	Thickness (m)
0	1.000	0.0	1000.0	0.0
1	0.995	38.0	995.5	38.0
2	0.988	91.5	989.2	53.5
3	0.980	152.9	982.0	61.4
4	0.970	230.3	973.0	77.3
5	0.956	339.5	960.4	109.2
6	0.938	481.6	944.2	142.1
7	0.916	658.1	924.4	176.4
8	0.893	845.8	903.7	187.8
9	0.868	1053.9	881.2	208.1
10	0.839	1300.7	855.1	246.8
11	0.808	1571.4	827.2	270.7
12	0.777	1849.6	799.3	278.2
13	0.744	2154.5	769.6	304.9
14	0.702	2556.6	731.8	402.1
15	0.648	3099.0	683.2	542.4
16	0.582	3805.8	623.8	706.8
17	0.500	4763.7	550.0	957.9
18	0.400	6082.5	460.0	1318.8
19	0.300	7627.9	370.0	1545.5
20	0.200	9510.5	280.0	1882.6
21	0.120	11465.1	208.0	1954.6
22	0.052	13750.2	146.0	2285.1
23	0.000	16262.4	100.0	2512.1

CMAQ Domain

Clean boundary conditions and initial conditions using EPA defaults with some updates.



CMAQ Description

- Domain:
  - 85 columns, 95 rows, 18 layers, 36km grid cells horizontally
  - 68 variables,
  - Lambert-Conformal Projection
- Emissions:
  - Area, Mobile, Point (Mexico), Biogenics: version F
  - Point, Road Dust, Fire: version G
- Meteorology:
  - From EPA MM5 1996 simulation, processed with MCIP v.1
- Chemistry: CB-IV with extensions
  - SO2 oxidation into sulfate aerosol
  - VOC oxidation into secondary organic aerosol
  - Coupled with RADM aqueous chemistry

Vertical Layer Structure – Sigma Coordinates

Layers	Layer_23	Layer_18	Layer_17	Layer_16b	Layer_16a	Layer_12	Layer_08
23	0	0	0	0	0	0	0
22	0.052						
21	0.12						0.12
20	0.2	0.2	0.2	0.2	0.2	0.2	
19	0.3						0.3
18	0.4					0.4	
17	0.5	0.5	0.5	0.5	0.5		0.5
16	0.582					0.582	
15	0.648	0.648	0.648	0.648	0.648	0.648	
14	0.702	0.702	0.702		0.702	0.702	0.702
13	0.744	0.744	0.744	0.744	0.744		
12	0.777	0.777	0.777		0.777	0.777	
11	0.808	0.808	0.808	0.808	0.808		
10	0.839	0.839	0.839	0.839	0.839	0.839	0.839
9	0.868	0.868	0.868	0.868	0.868		
8	0.893	0.893	0.893	0.893	0.893	0.893	
7	0.916	0.916	0.916	0.916	0.916		
6	0.938	0.938	0.938	0.938	0.938	0.938	0.938
5	0.956	0.956	0.956	0.956	0.956		
4	0.97	0.97		0.97		0.97	
3	0.98	0.98	0.98	0.98	0.98		0.98
2	0.988	0.988	0.988	0.988	0.988	0.988	
1	0.995	0.995	0.995	0.995			
0	1	1	1	1	1	1	1

WRAP Modeling Domain
CCTM CPU Time and Disk Storage

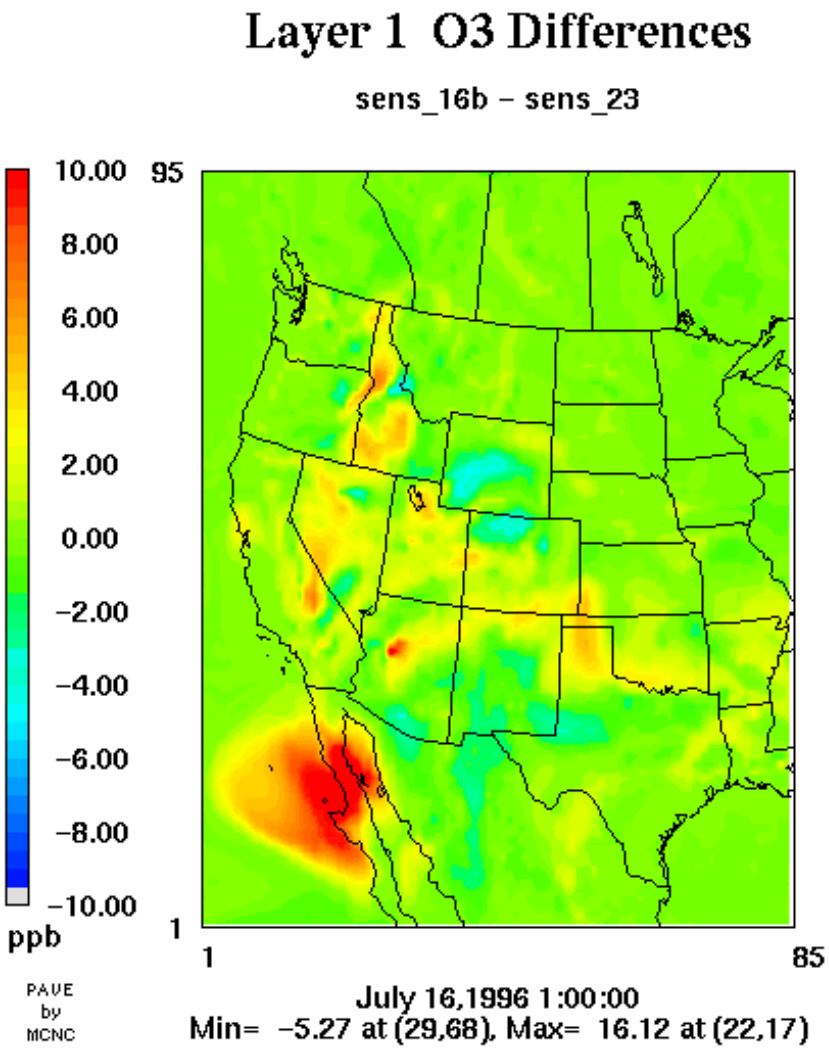
(Redhat 7.3, PGF90 v.4.0-1, Athlon 1.6 Ghz)

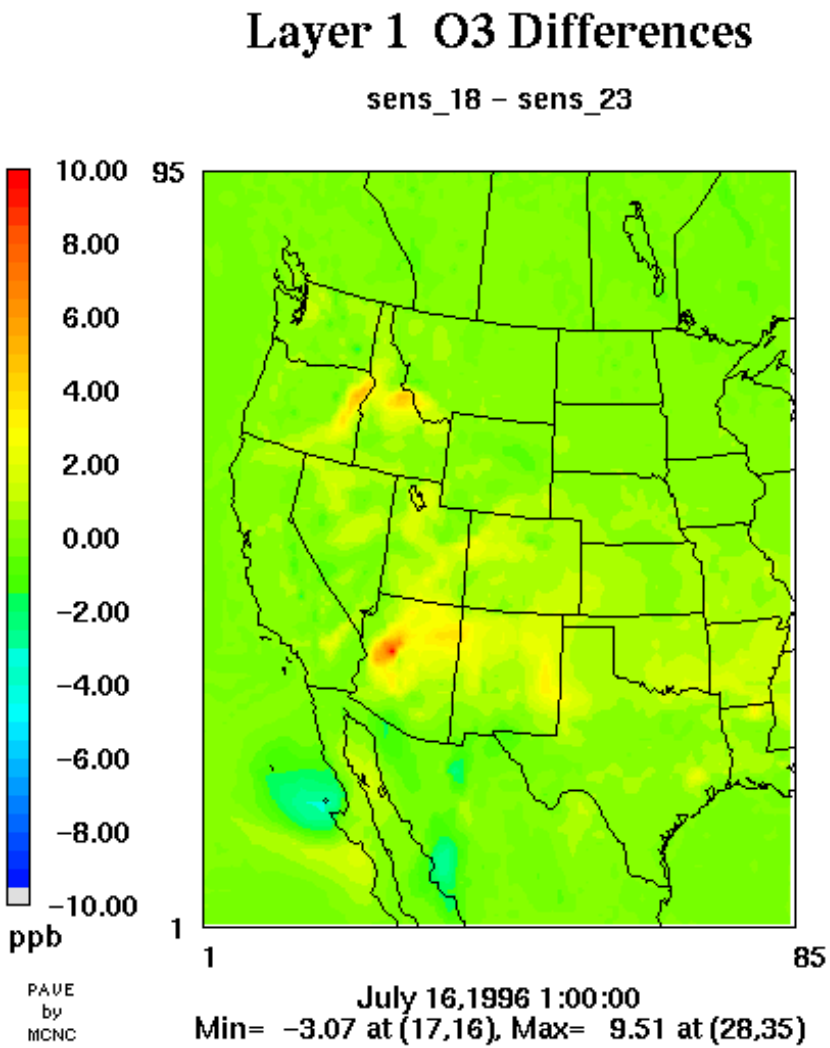
CPU	8L	12L	16aL	18L	23L
Jan	0:34:12	0:52:57	1:25:05	2:11:59	3:25:30
July	0:36:22	0:56:13	1:19:14	1:40:45	2:38:36

	8L	12L	16aL	18L	23L
File size	473M	682M	892M	997M	1.3G

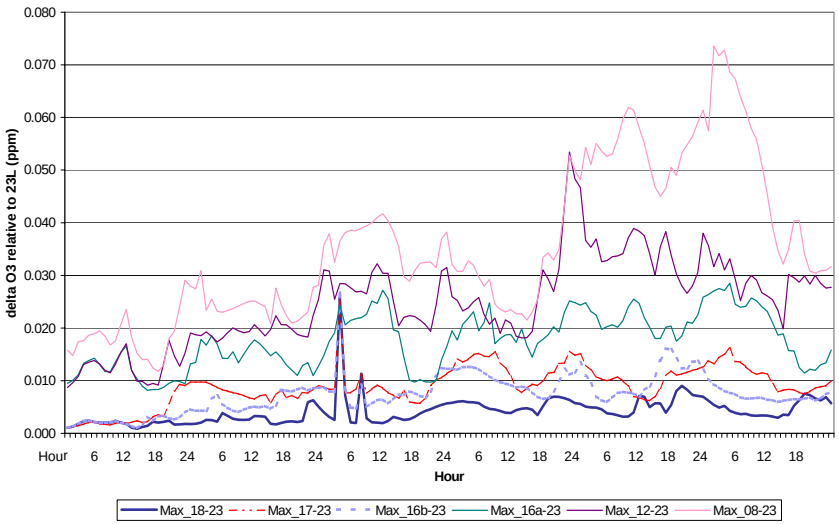
Vertical Layer Structure Comparison

- Statistics for the differences in Layer 1 ozone:
  - July 1-6, 1996 Layer 1 Ozone Differences for the six cases
    - maximum differences
    - minimum differences
    - mean of differences
    - sigma of differences
  - July 1-6, 1996 Layer 6 Ozone Differences
  - July 16-21, 1996 Layer 1 Ozone Differences
- Layer 1 Spatial Differences
  - Ozone
  - Deciview
- Vertical Ozone Differences Plots
  - Rows 31

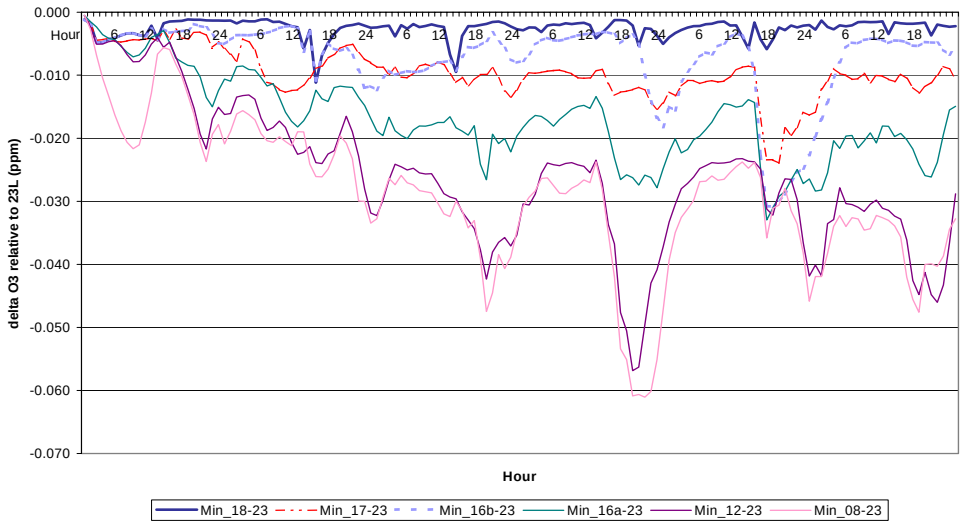

Layer 1 O3 Differences
sens_16b – sens_23
10.00
8.00
6.00
4.00
2.00
0.00
−2.00
−4.00
−6.00
−8.00
−10.00
ppb
95
1
1
85
PAVE by MCNC
July 16,1996 1:00:00
Min= −5.27 at (29,68), Max= 16.12 at (22,17)


Layer 1 O3 Differences
sens_18 – sens_23
10.00
8.00
6.00
4.00
2.00
0.00
−2.00
−4.00
−6.00
−8.00
−10.00
ppb
95
1
1
85
PAVE by MCNC
July 16,1996 1:00:00
Min= −3.07 at (17,16), Max= 9.51 at (28,35)

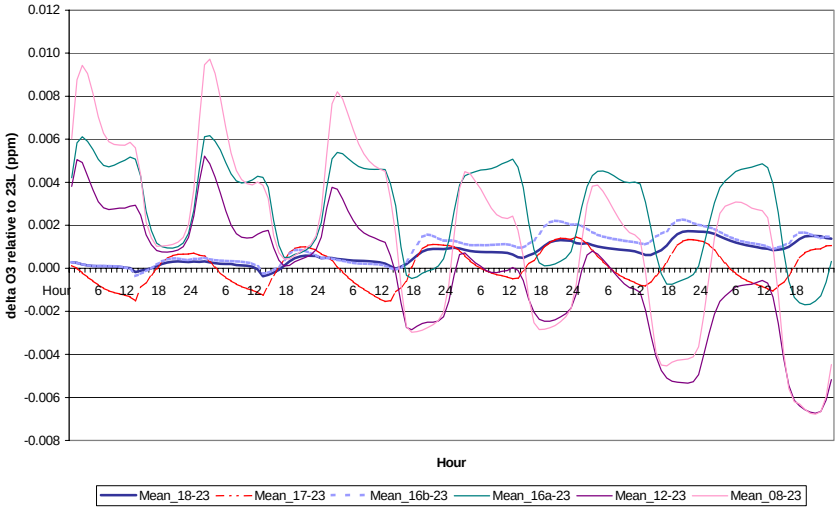
Statistical Differences in Vertical Layer Structures
Layer 1 - Ozone - Maximum
July 1-6, 1996



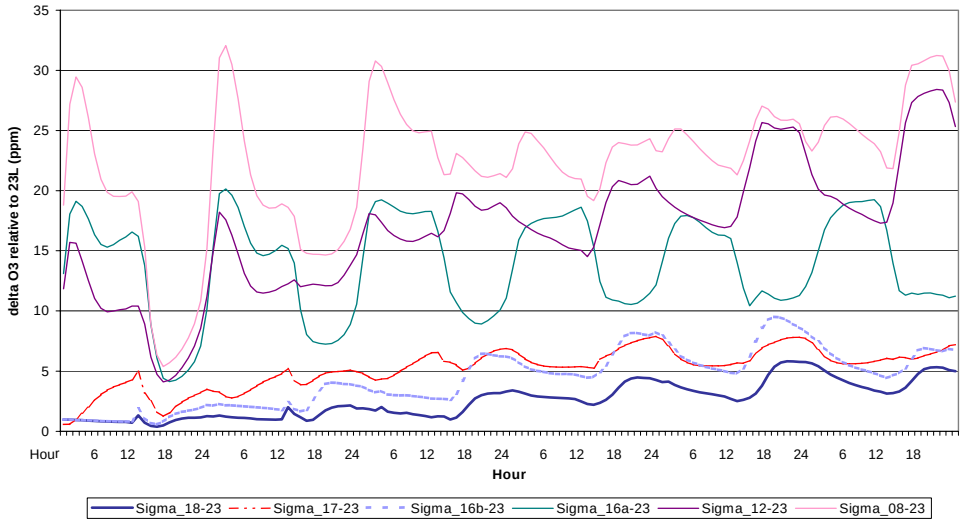
Statistical Differences in Vertical Layer Structures
Layer 1 - Ozone - Minimum
July 1-6, 1996



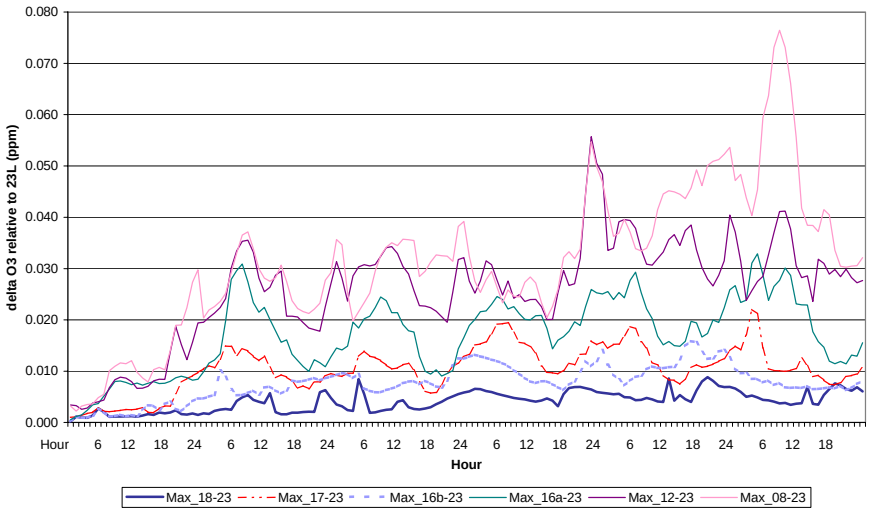
Statistical Differences in Vertical Layer Structures
Layer 1 - Ozone - Mean
July 1-6, 1996



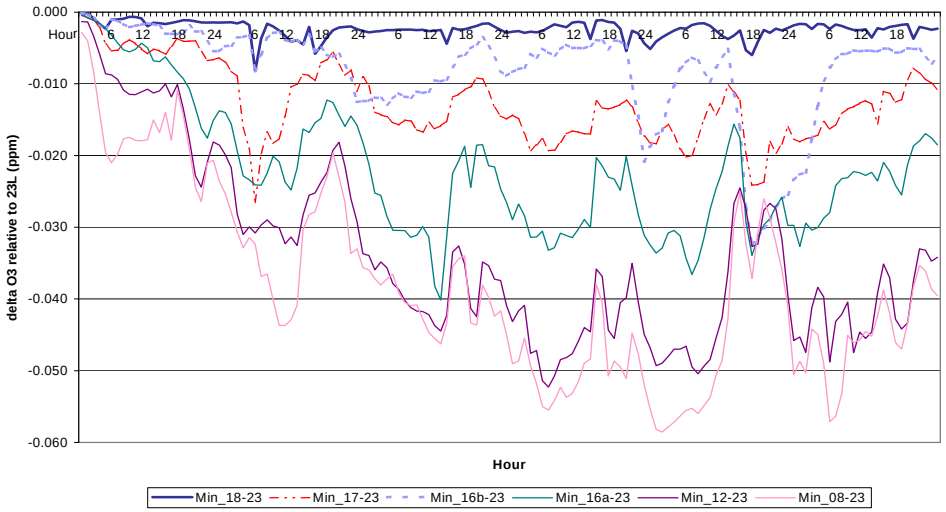
Statistical Differences in Vertical Layer Structures
Layer 1 - Ozone - Sigma
July 1-6, 1996



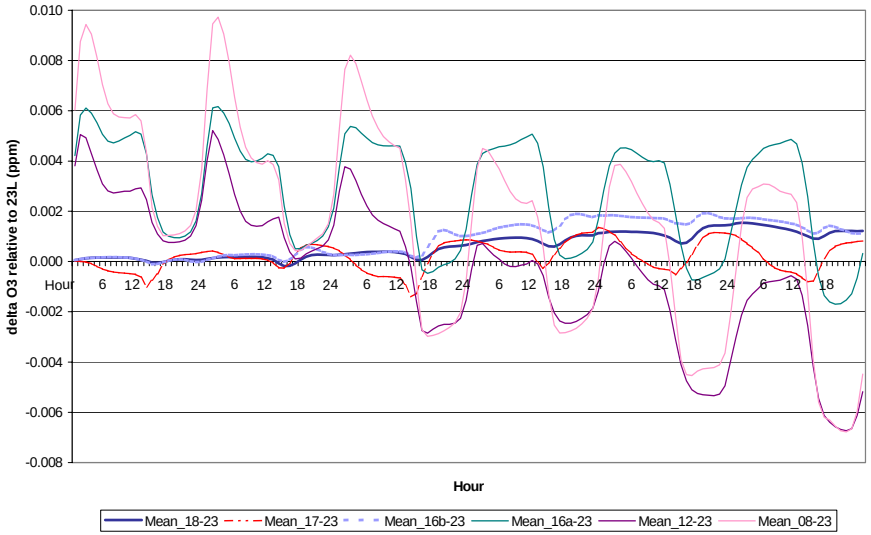
Statistical Differences in Vertical Layer Structures
Layer 6 - Ozone - Maximum
July 1-6, 1996



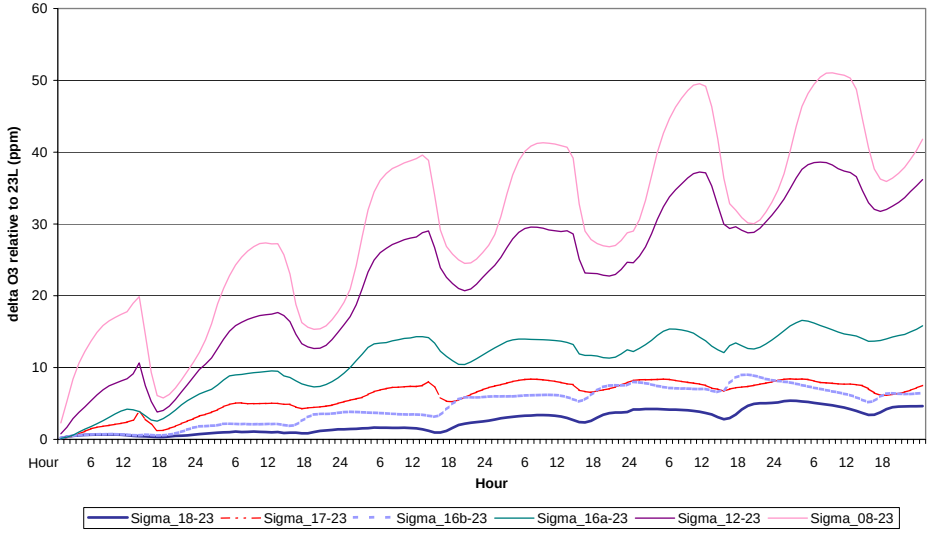
Statistical Differences in Vertical Layer Structures
Layer 6 - Ozone - Minimum
July 1-6, 1996



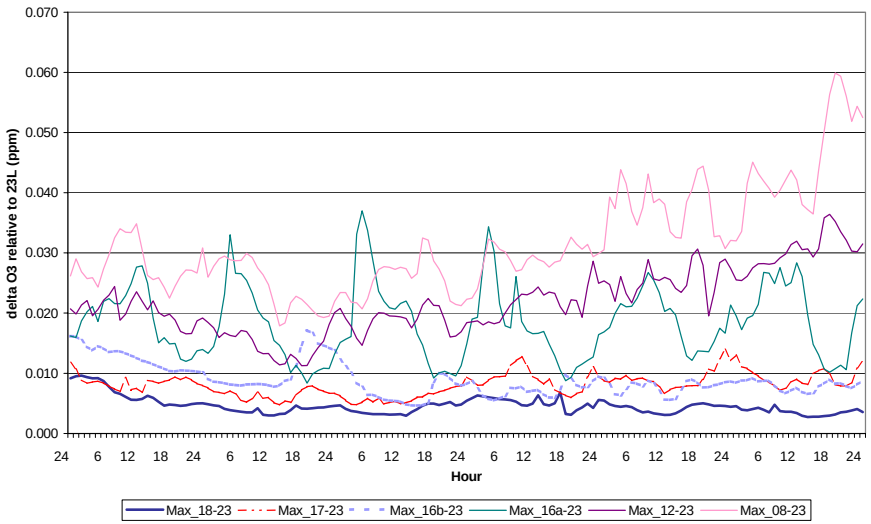
Statistical Differences in Vertical Layer Structures
Layer 6 - Ozone - Mean
July 1-6, 1996



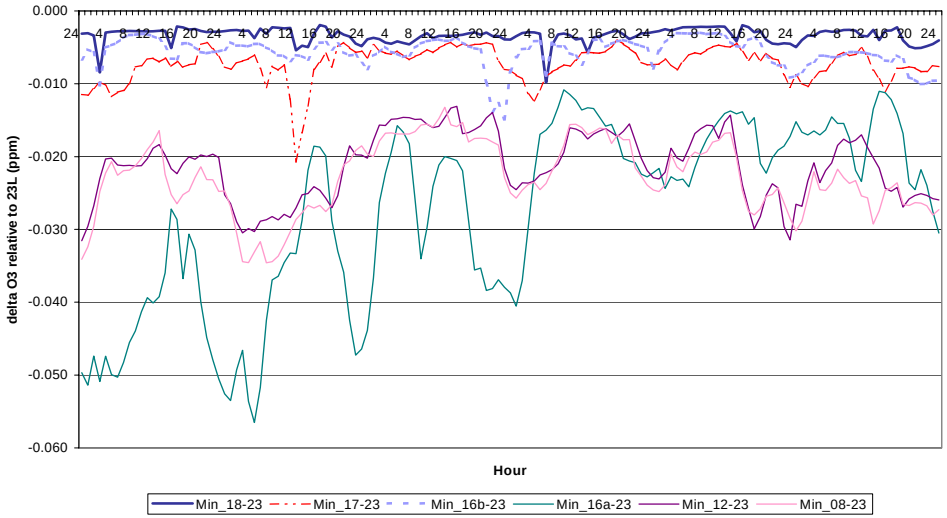
Statistical Differences in Vertical Layer Structures
Layer 6 - Ozone - Sigma
July 1-6, 1996



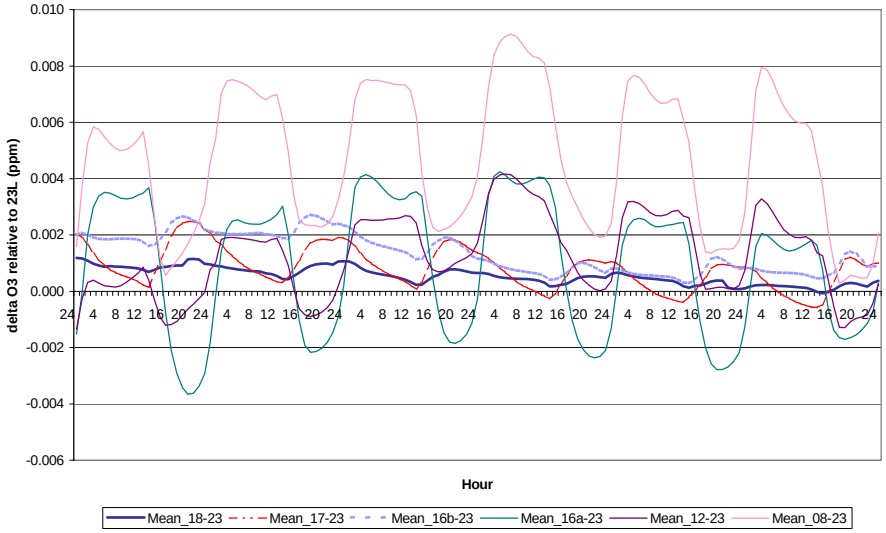
Statistical Differences in Vertical Layer Structures
Layer 1 - Ozone - Maximum
July 16-21, 1996



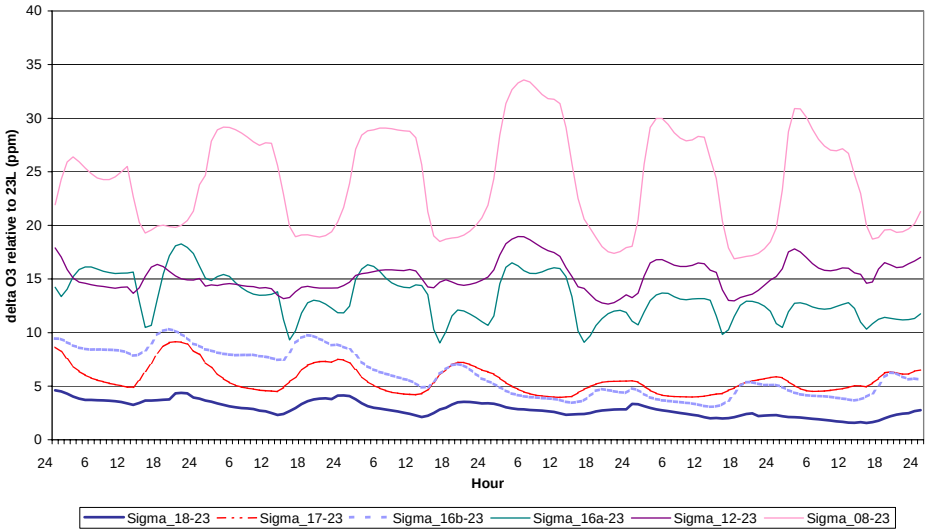
Statistical Differences in Vertical Layer Structures
Layer 1 - Ozone - Minimum
July 16-21, 1996



Statistical Differences in Vertical Layer Structures
Layer 1 - Ozone - Mean
July 16-21, 1996

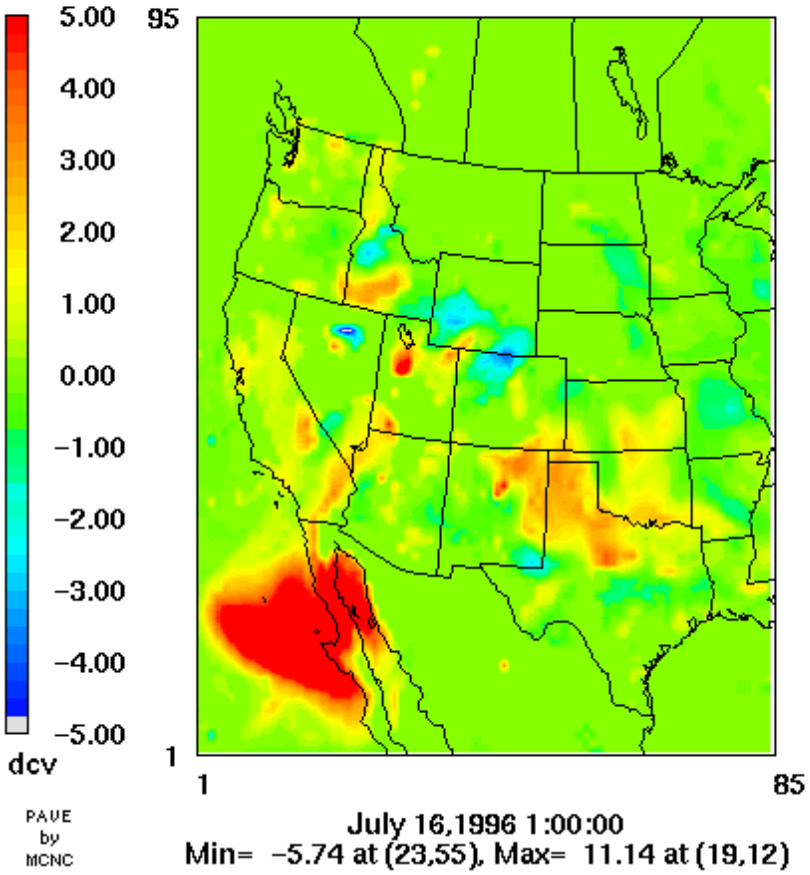


Statistical Differences in Vertical Layer Structures
Layer 1 - Ozone - Sigma
July 16-21, 1996



Layer 1 DCV_Recon Differences

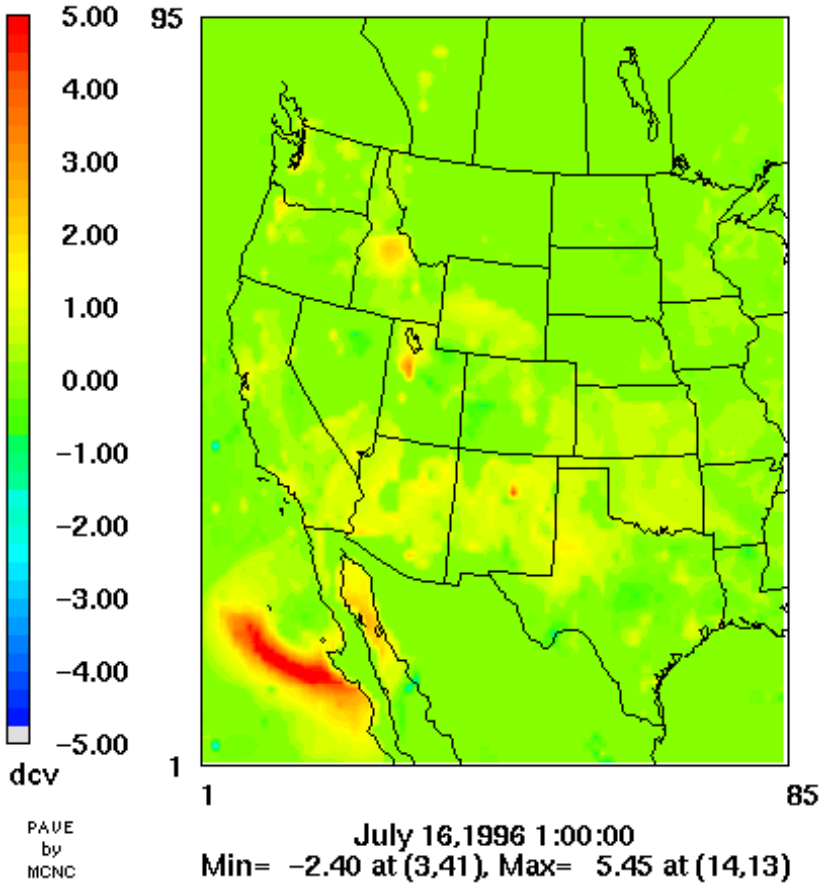
sens_16b – sens_23



July 16,1996 1:00:00
Min= −5.74 at (23,55), Max= 11.14 at (19,12)

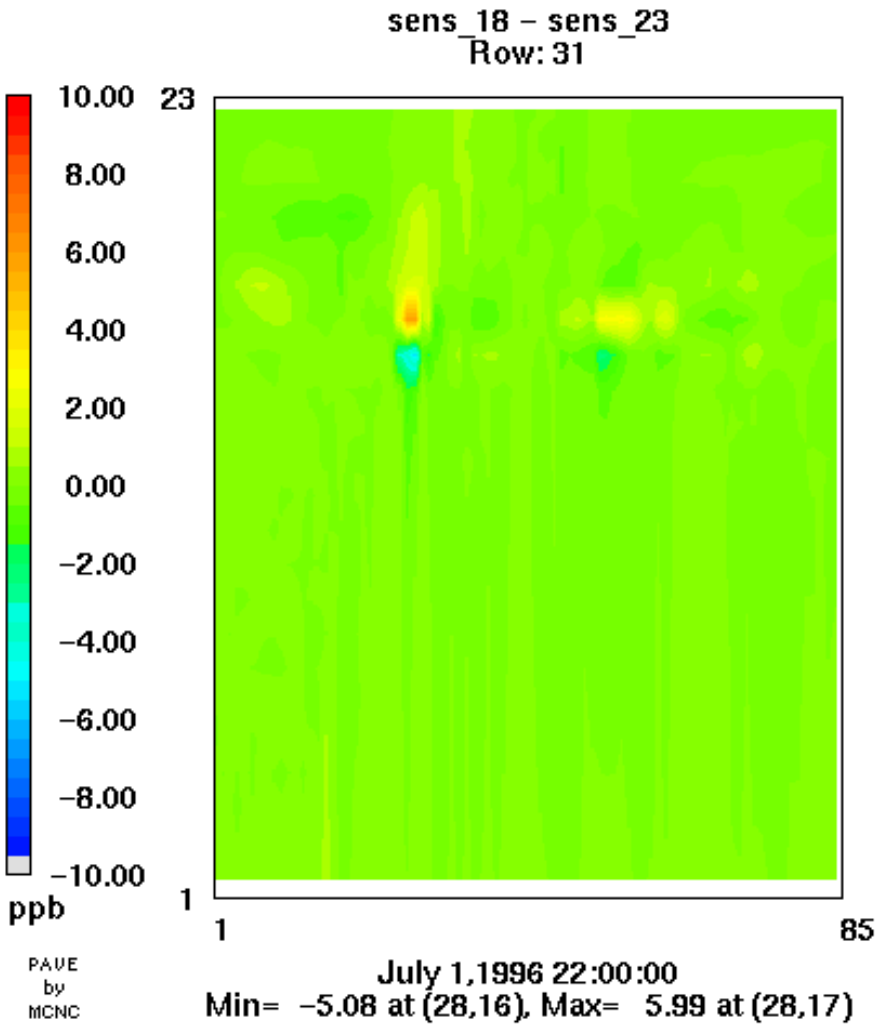
Layer 1 DCV_Recon Differences

sens_18 – sens_23

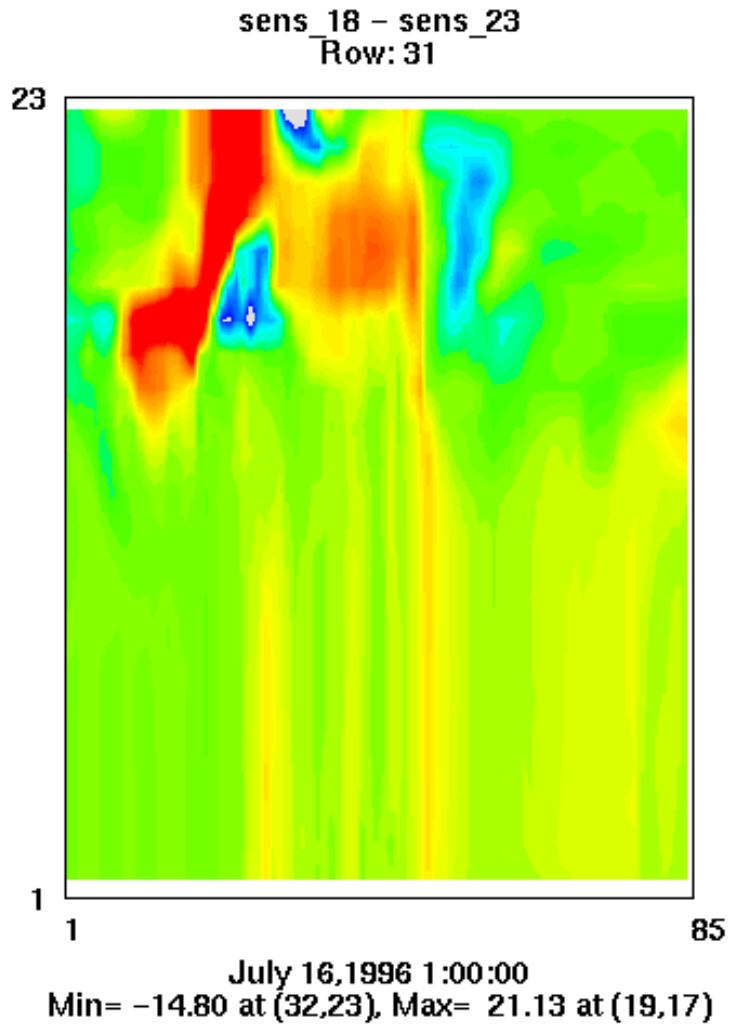


July 16,1996 1:00:00
Min= −2.40 at (3,41), Max= 5.45 at (14,13)

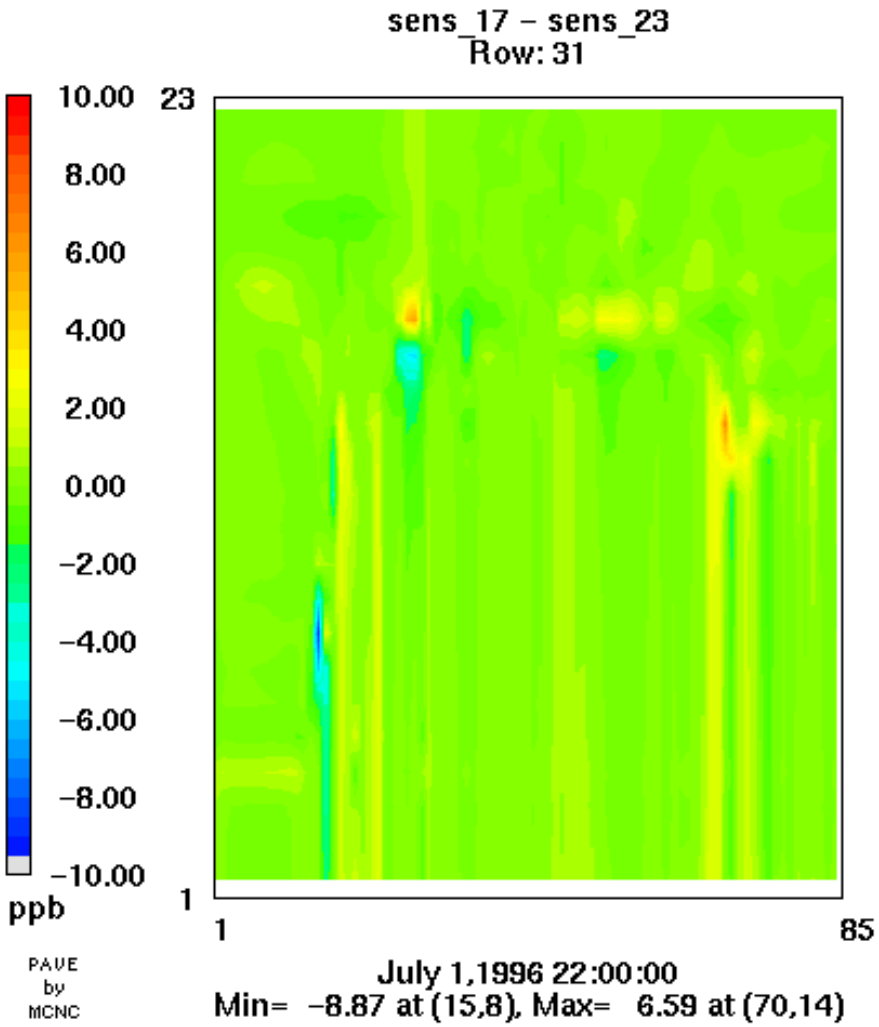
Vertical O3 Differences



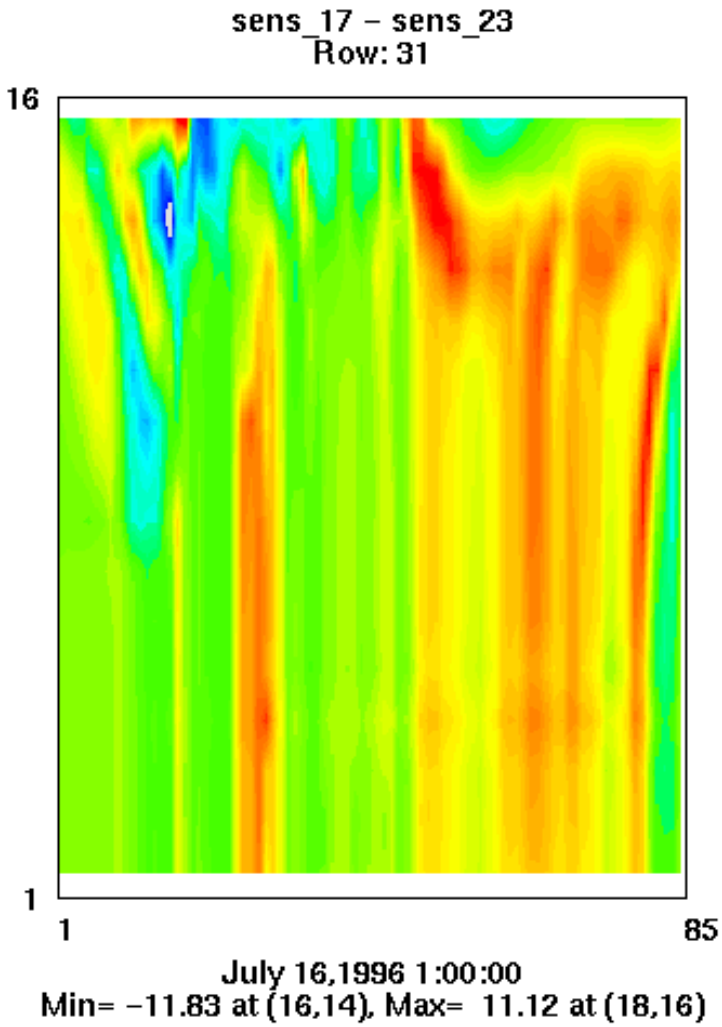
Vertical O3 Differences



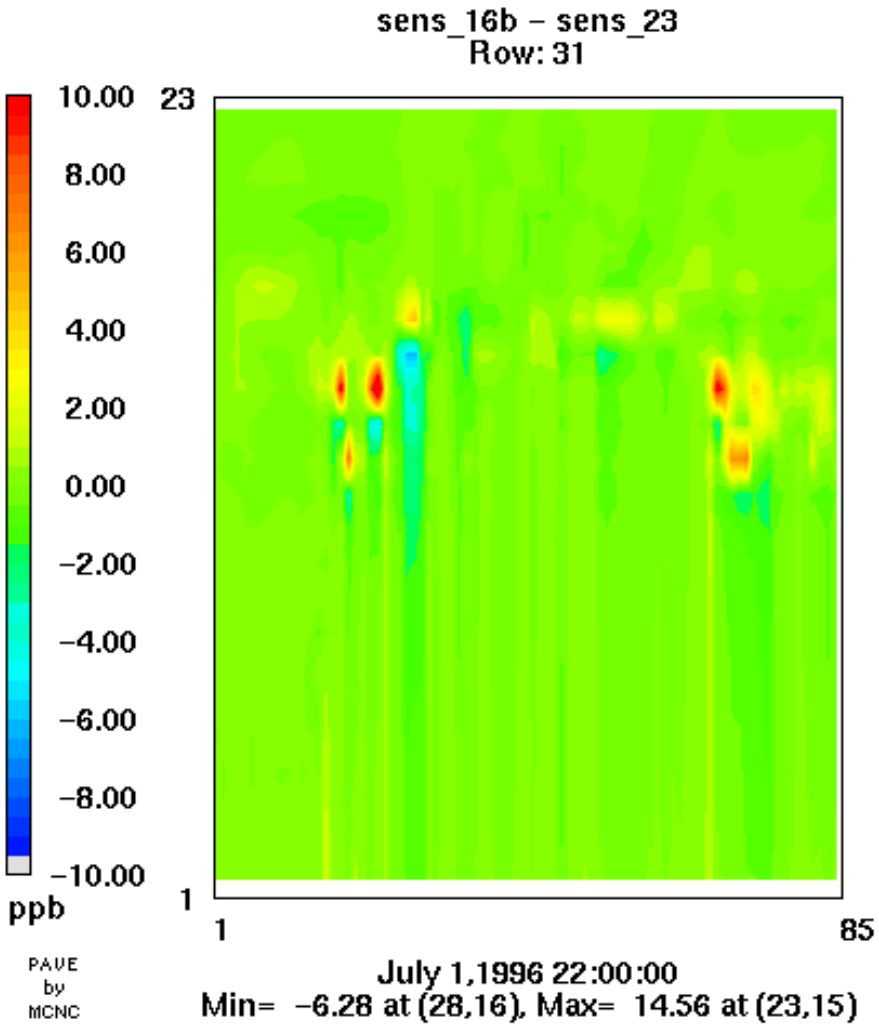
Vertical O3 Differences



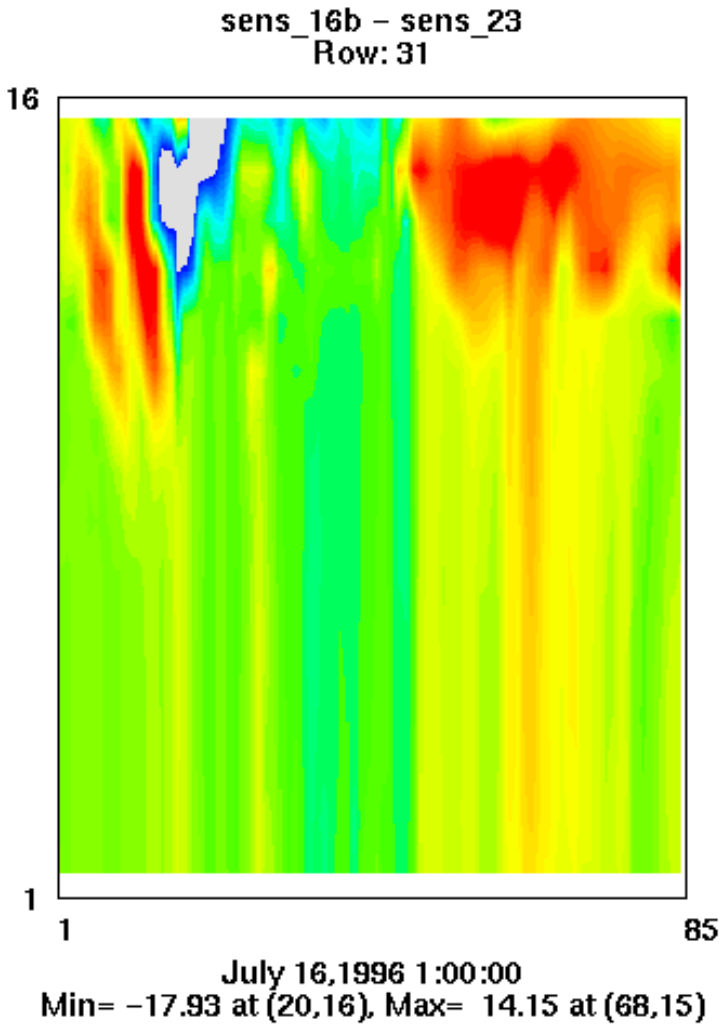
Vertical O3 Differences



Vertical O3 Differences



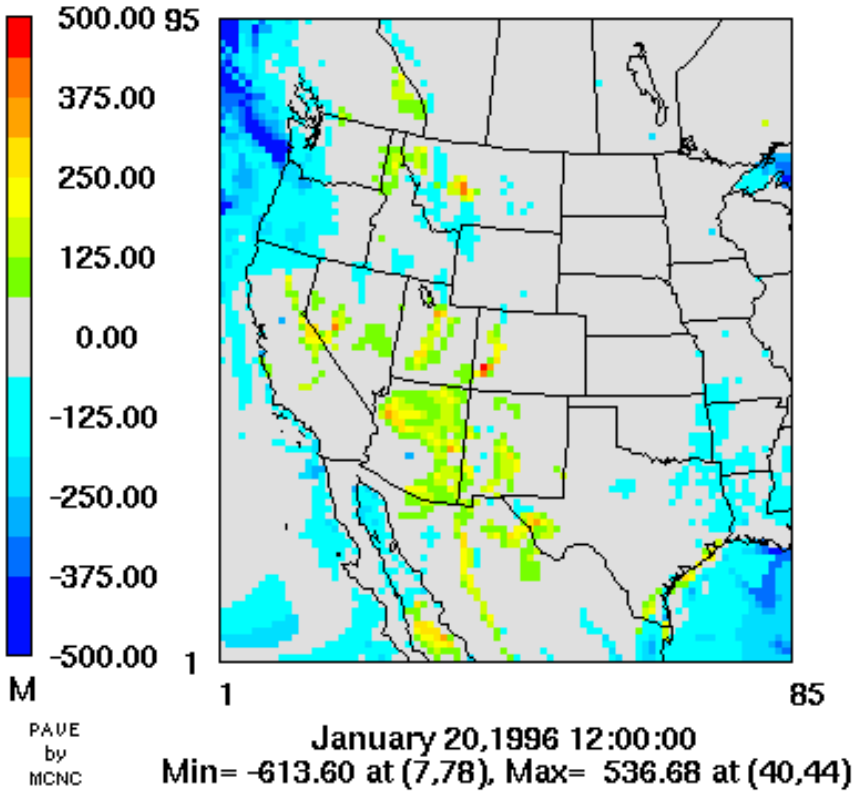
Vertical O3 Differences



Application of MCIP v1 vs. MCIP v2

PBL: MCIP2 - MCIP1

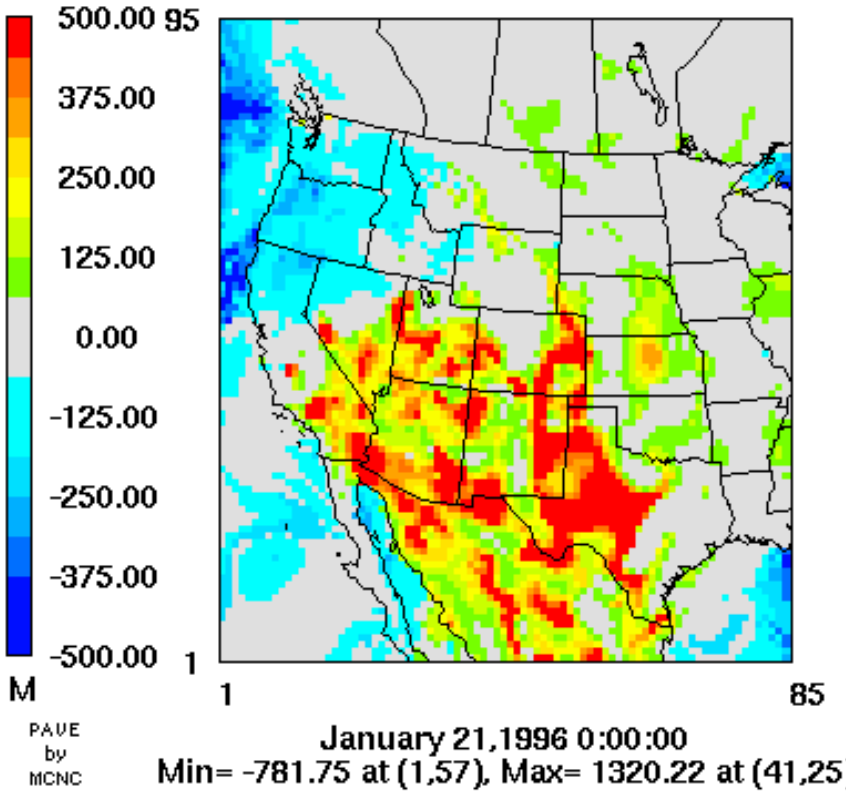
WRAP Jan., 23 Layer, Layer 1



January 20,1996 12:00:00
Min= -613.60 at (7,78), Max= 536.68 at (40,44)

PBL: MCIP2 - MCIP1

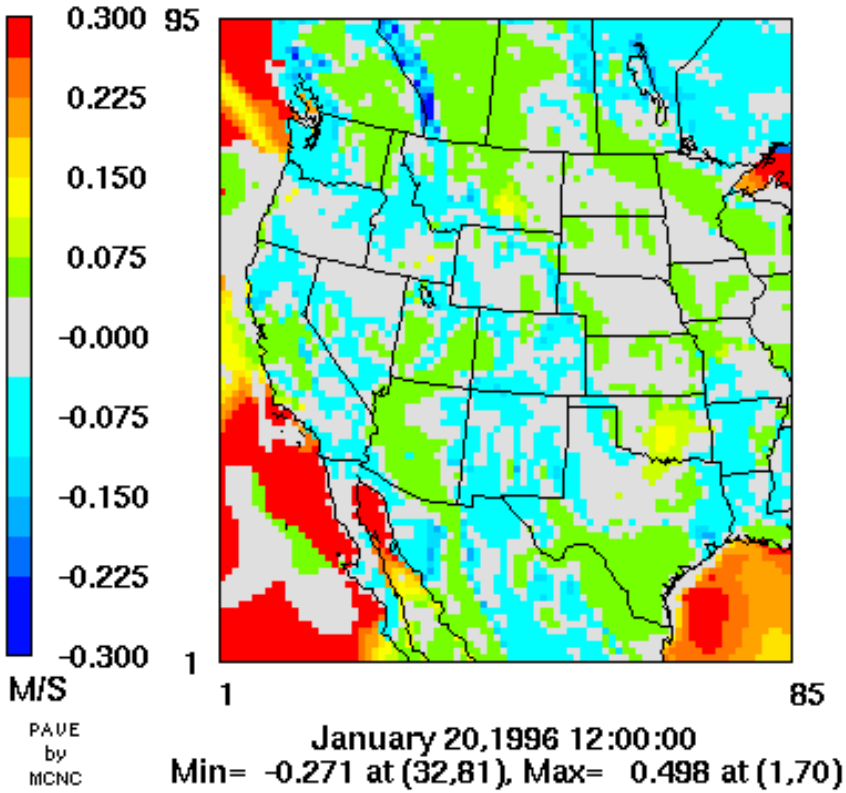
WRAP Jan., 23 Layer, Layer 1



January 21,1996 0:00:00
Min= -781.75 at (1,57), Max= 1320.22 at (41,25)

USTAR: MCIP2 - MCIP1

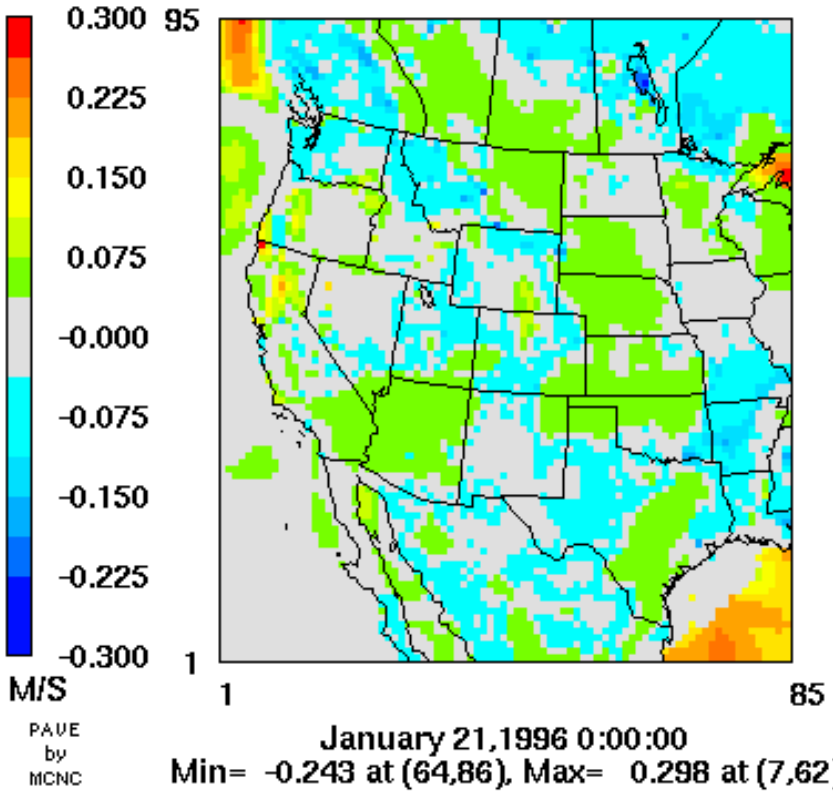
WRAP Jan., 23 Layer, Layer 1



January 20,1996 12:00:00
Min= -0.271 at (32,81), Max= 0.498 at (1,70)

USTAR: MCIP2 - MCIP1

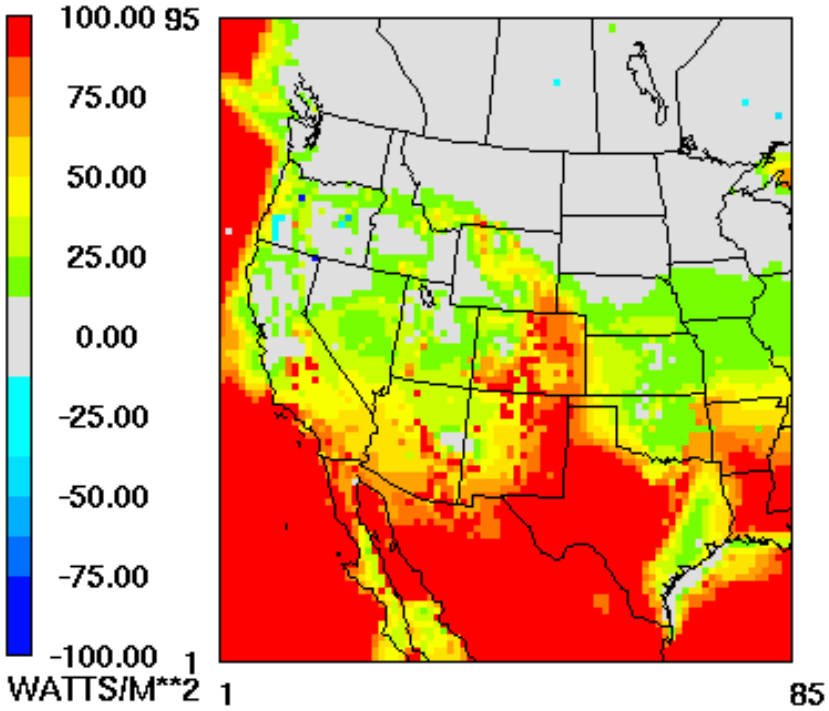
WRAP Jan., 23 Layer, Layer 1



January 21,1996 0:00:00
Min= -0.243 at (64,86), Max= 0.298 at (7,62)

Latent Heat Flux (QFX)

WRAP Jan., 23 Layers, Layer 1
MCIP2 - MCIP1

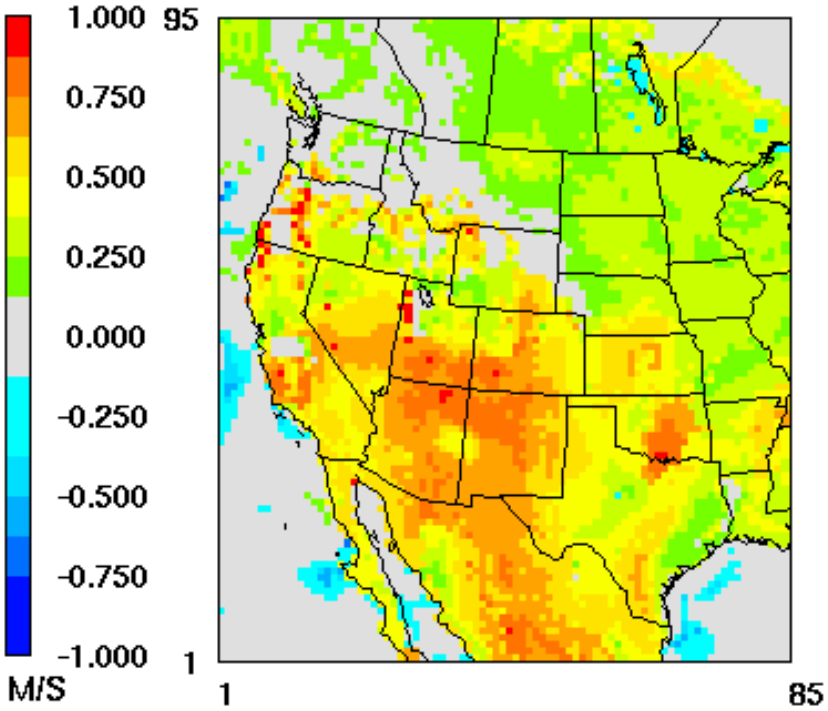


PAVE by MCNC

January 20,1996 20:00:00
Min= -139.27 at (13,69), Max= 388.33 at (19,19)

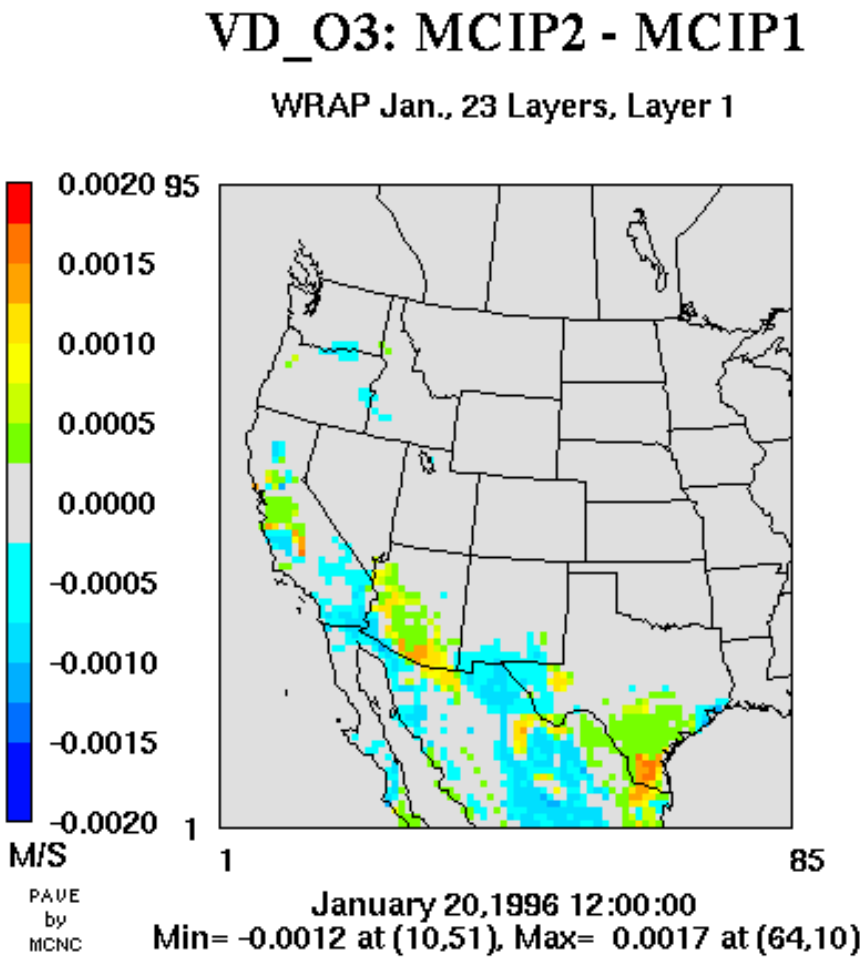
WSTAR: MCIP2 - MCIP1

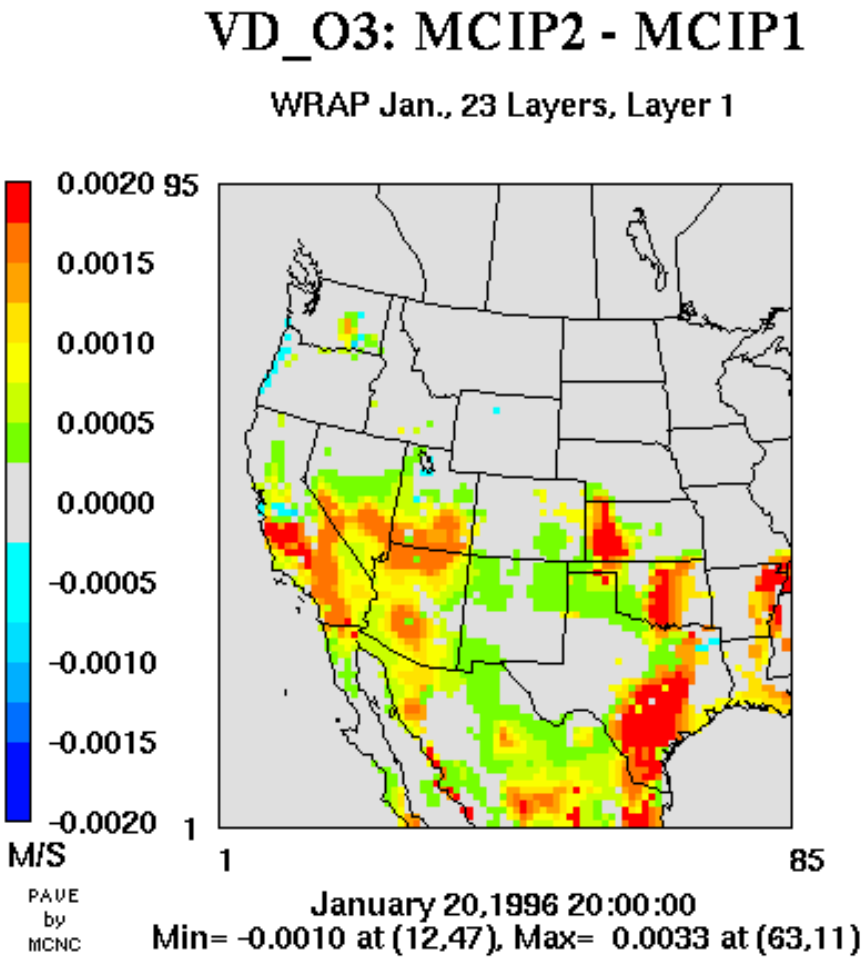
WRAP Jan., 23 Layers, Layer 1



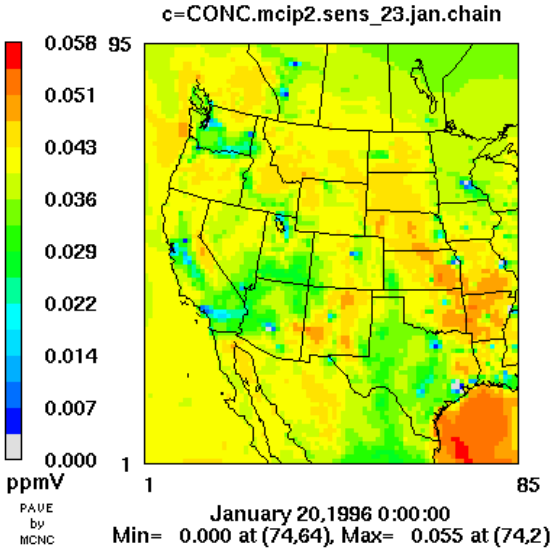
PAVE by MCNC

January 20,1996 20:00:00
Min= -0.709 at (20,18), Max= 1.177 at (18,47)

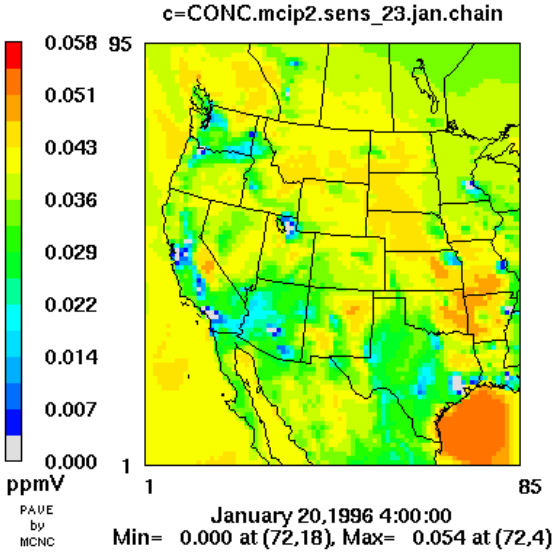

VD_O3: MCIP2 - MCIP1
WRAP Jan., 23 Layers, Layer 1
0.0020
0.0015
0.0010
0.0005
0.0000
-0.0005
-0.0010
-0.0015
-0.0020
M/S
95
1
1
85
PAVE by MCNC
January 20,1996 12:00:00
Min= -0.0012 at (10,51), Max= 0.0017 at (64,10)


VD_O3: MCIP2 - MCIP1
WRAP Jan., 23 Layers, Layer 1
0.0020
0.0015
0.0010
0.0005
0.0000
-0.0005
-0.0010
-0.0015
-0.0020
M/S
95
1
1
85
PAVE by MCNC
January 20,1996 20:00:00
Min= -0.0010 at (12,47), Max= 0.0033 at (63,11)

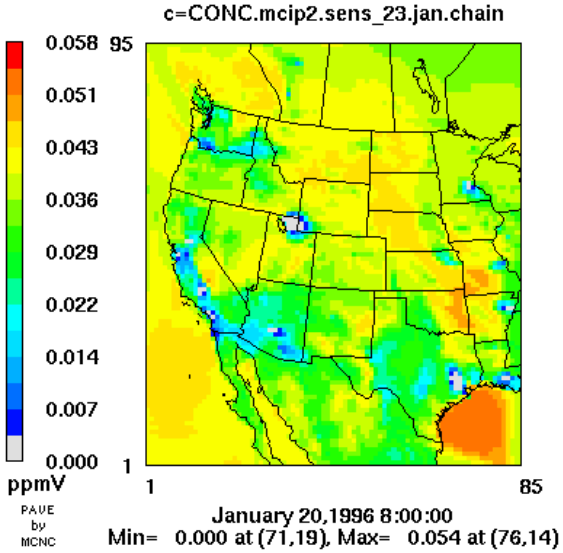
Layer 1 O3c



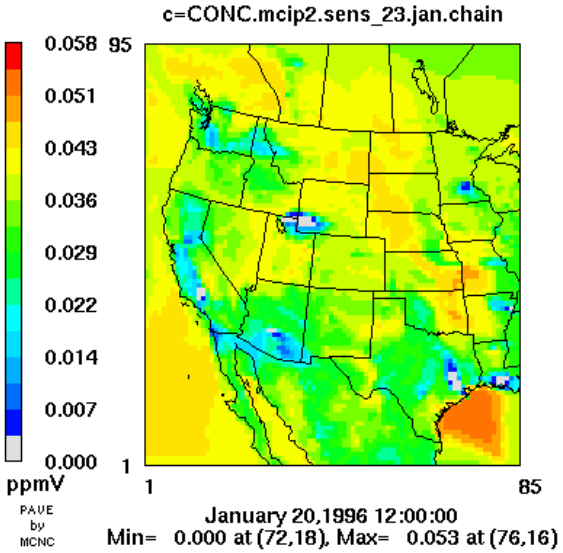
Layer 1 O3c



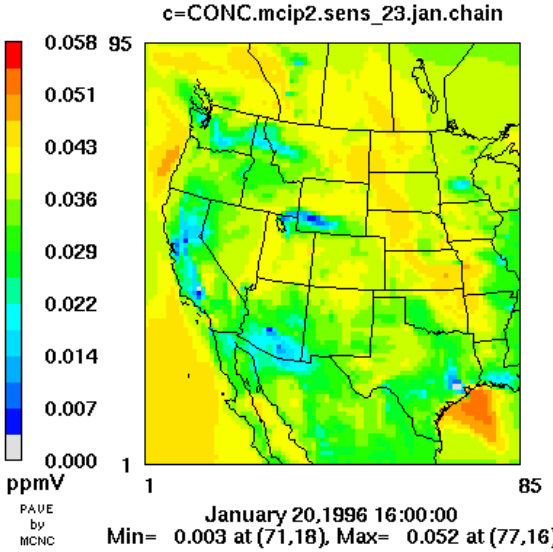
Layer 1 O3c



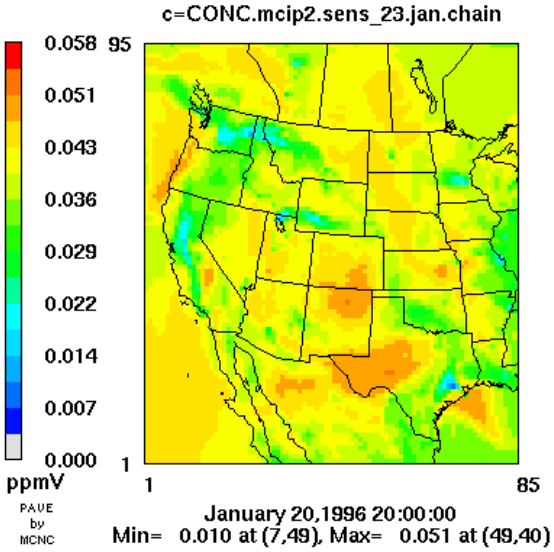
Layer 1 O3c



Layer 1 O3c

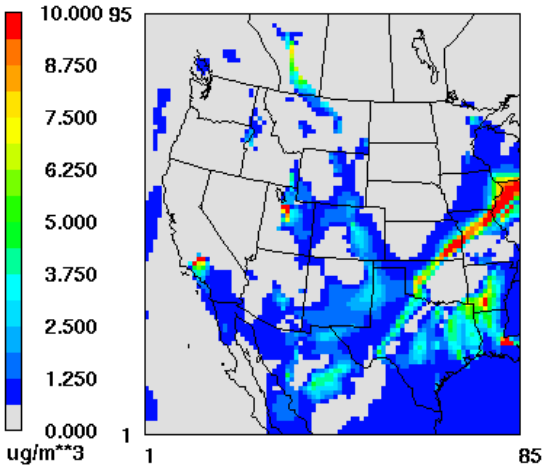


Layer 1 O3c



Layer 1 ASO4

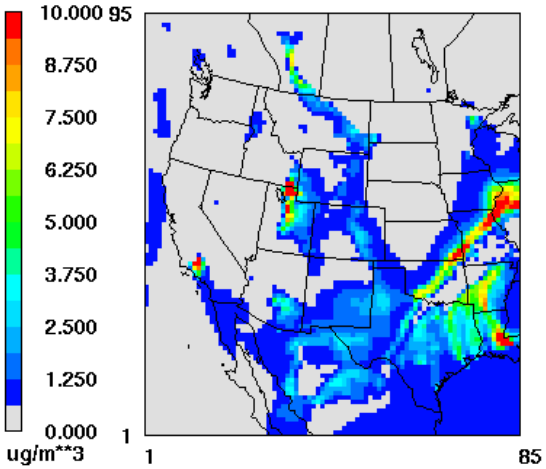
MCIP2, 23 Layers, Layer 1



January 23,1996 8:00:00
Min= 0.001 at (5,65), Max= 60.765 at (83,21)

Layer 1 ASO4

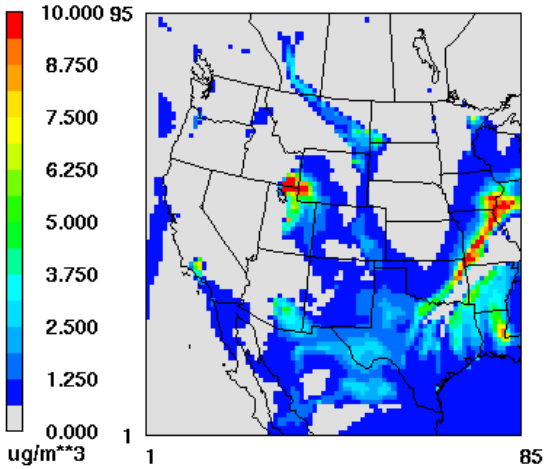
MCIP2, 23 Layers, Layer 1



January 23,1996 12:00:00
Min= 0.002 at (5,62), Max= 54.297 at (83,21)

Layer 1 ASO4

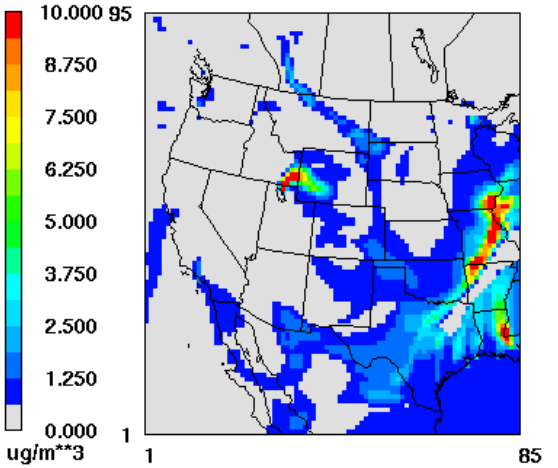
MCIP2, 23 Layers, Layer 1



January 23,1996 16:00:00
Min= 0.002 at (13,68), Max= 44.953 at (33,56)

Layer 1 ASO4

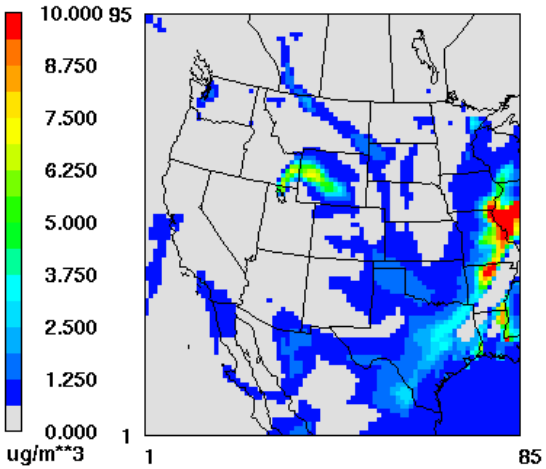
MCIP2, 23 Layers, Layer 1



January 23,1996 20:00:00
Min= 0.002 at (7,61), Max= 18.471 at (80,47)

Layer 1 ASO4

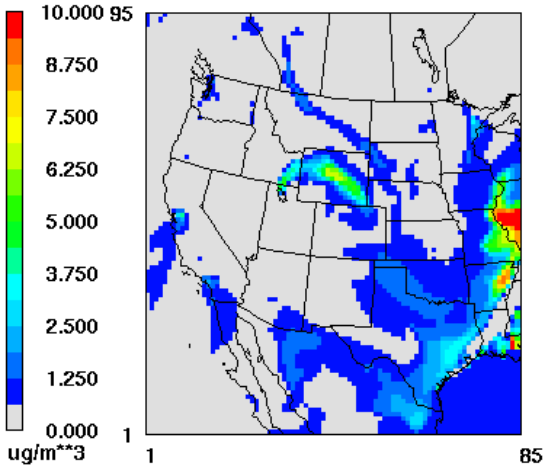
MCIP2, 23 Layers, Layer 1



January 24,1996 0:00:00
Min= 0.002 at (8,56), Max= 19.442 at (82,48)

Layer 1 ASO4

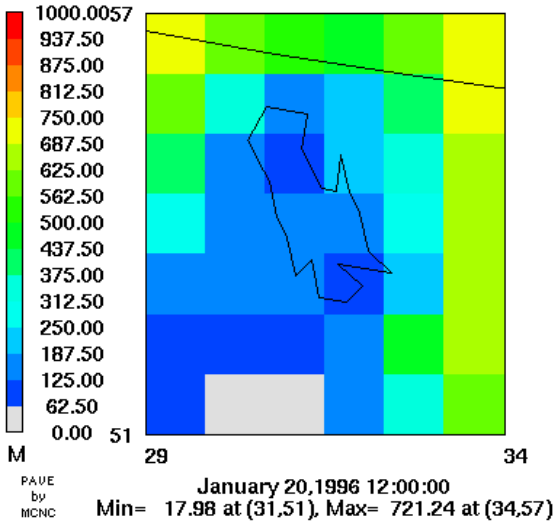
MCIP2, 23 Layers, Layer 1



January 24,1996 4:00:00
Min= 0.002 at (12,59), Max= 23.672 at (84,20)

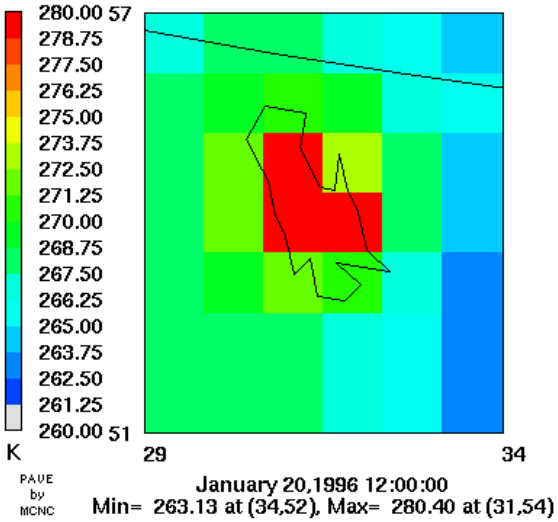
PBL Height

MCIP2, Great Salt Lake Region



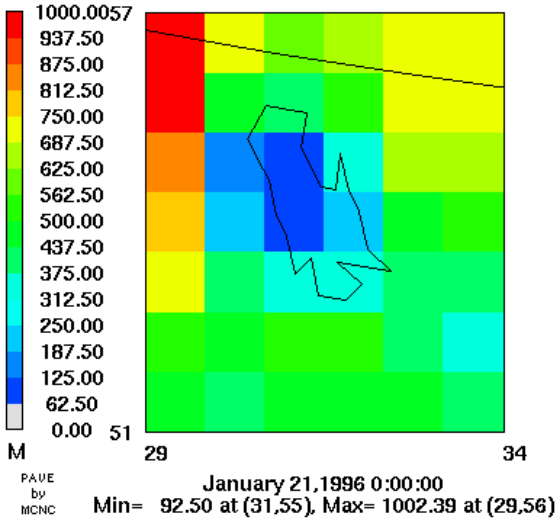
Air Temperature (TA)

MCIP2, Great Salt Lake Region



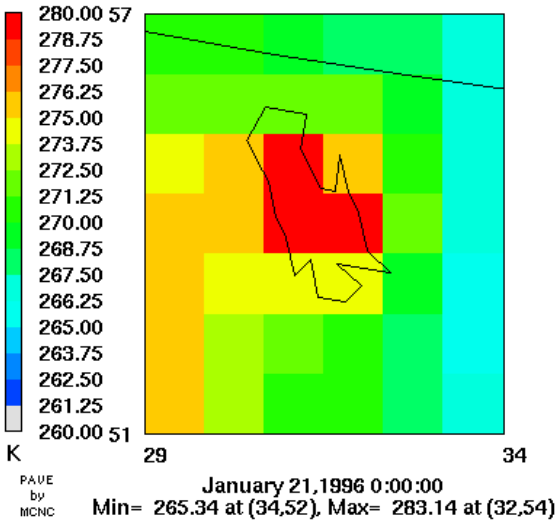
PBL Height

MCIP2, Great Salt Lake Region



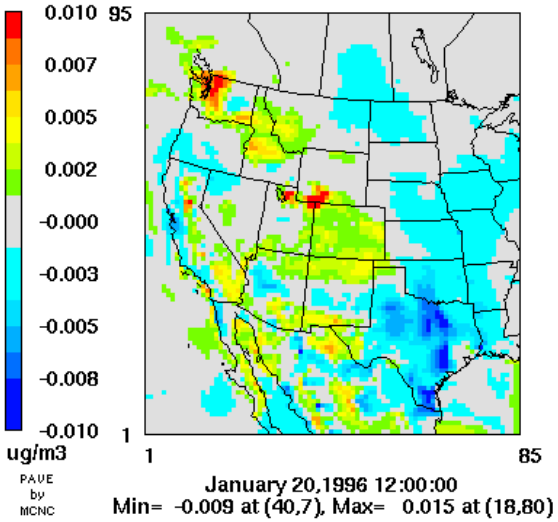
Air Temperature (TA)

MCIP2, Great Salt Lake Region



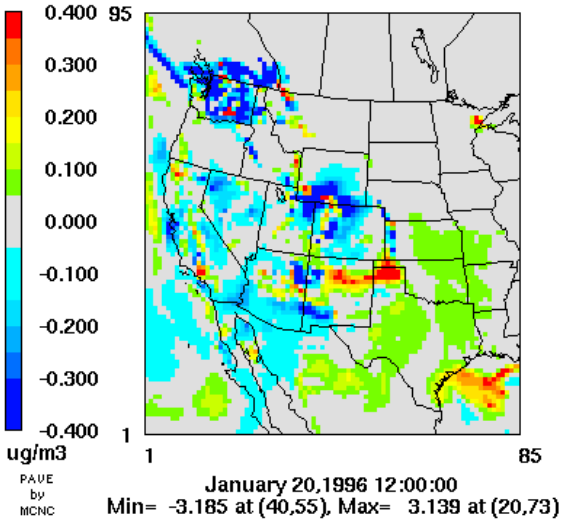
Delta O3: MCIP2 - MCIP1

WRAP Jan 1996, 23Layer, Layer 1



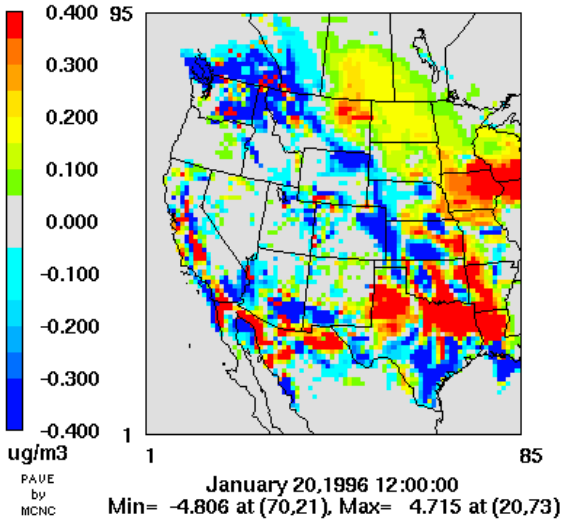
Delta ASO4: MCIP2 - MCIP1

WRAP Jan 1996, 23 Layer, Layer 1



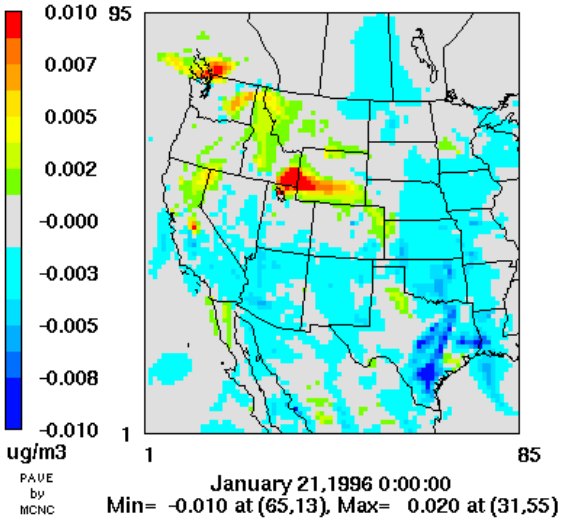
Delta ANO3: MCIP2 - MCIP1

WRAP Jan 1996, 23Layer, Layer 1



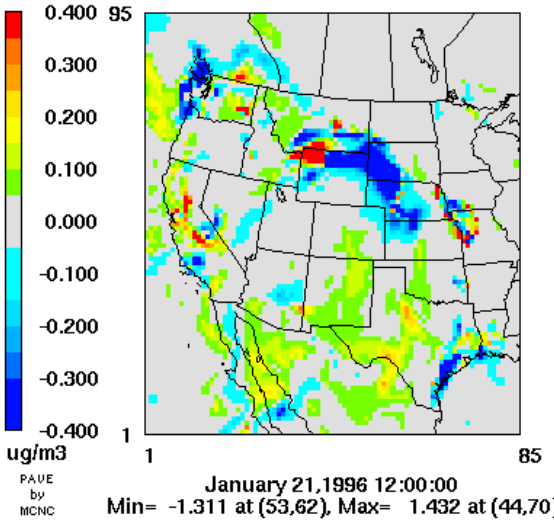
Delta O3: MCIP2 - MCIP1

WRAP Jan 1996, 23Layer, Layer 1



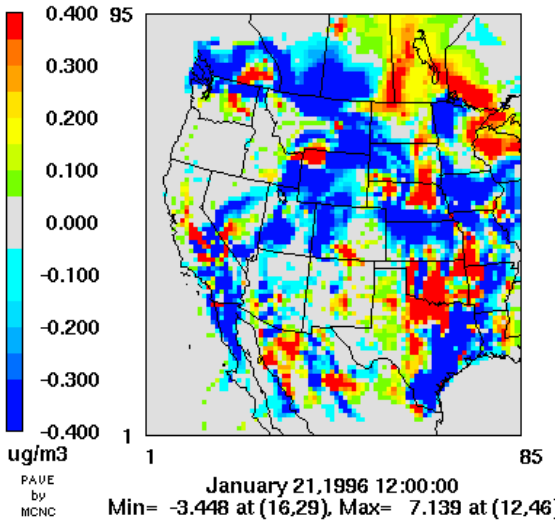
Delta ASO4: MCIP2 - MCIP1

WRAP Jan 1996, 23 Layer, Layer 1



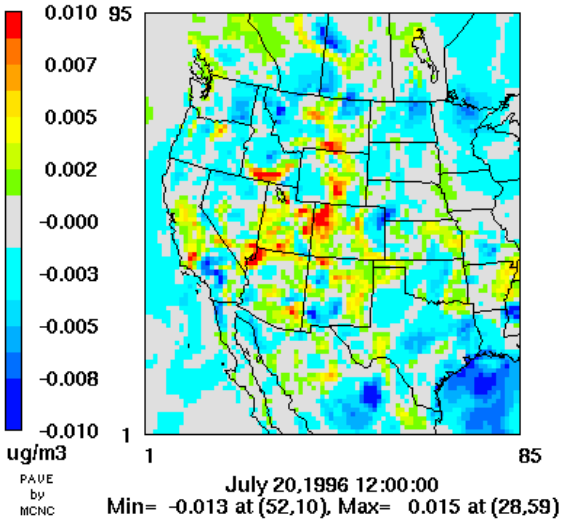
Delta ANO3: MCIP2 - MCIP1

WRAP Jan 1996, 23Layer, Layer 1



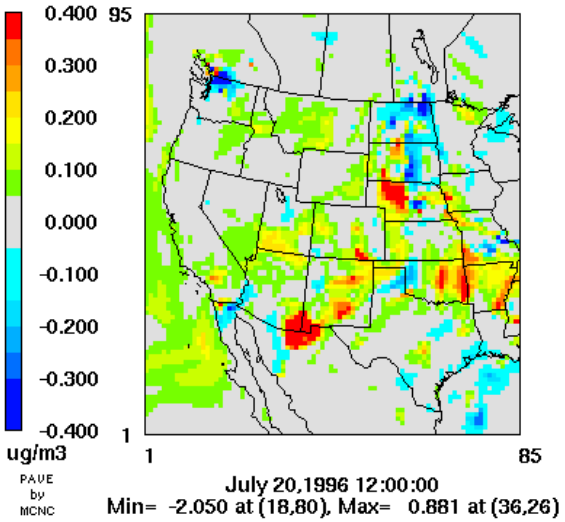
Delta O3: MCIP2 - MCIP1

WRAP July 1996, 23Layer, Layer 1



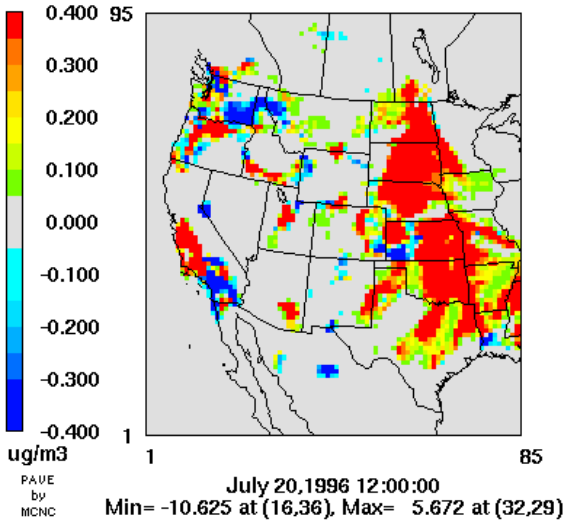
Delta ASO4: MCIP2 - MCIP1

WRAP July 1996, 23 Layer, Layer 1



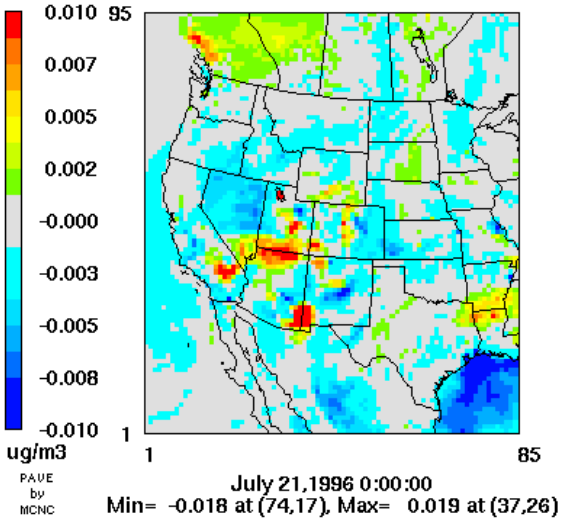
Delta ANO3: MCIP2 - MCIP1

WRAP July 1996, 23Layer, Layer 1



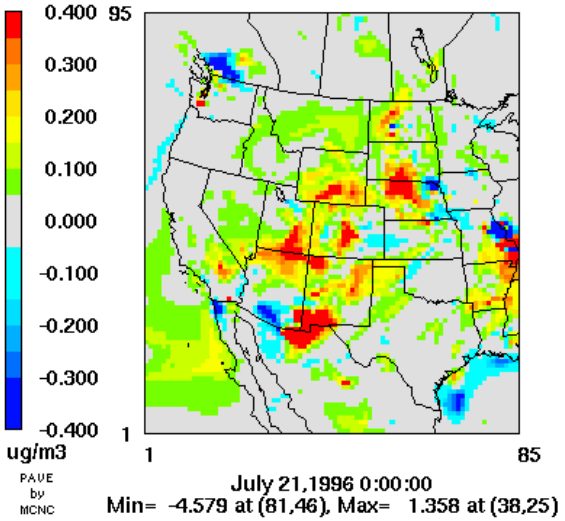
Delta O3: MCIP2 - MCIP1

WRAP July 1996, 23Layer, Layer 1



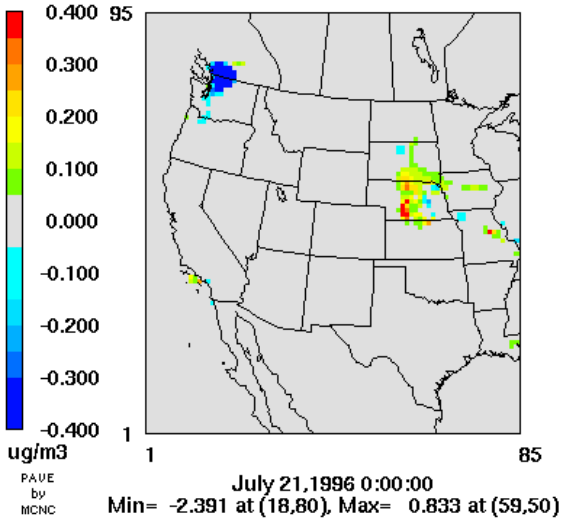
Delta ASO4: MCIP2 - MCIP1

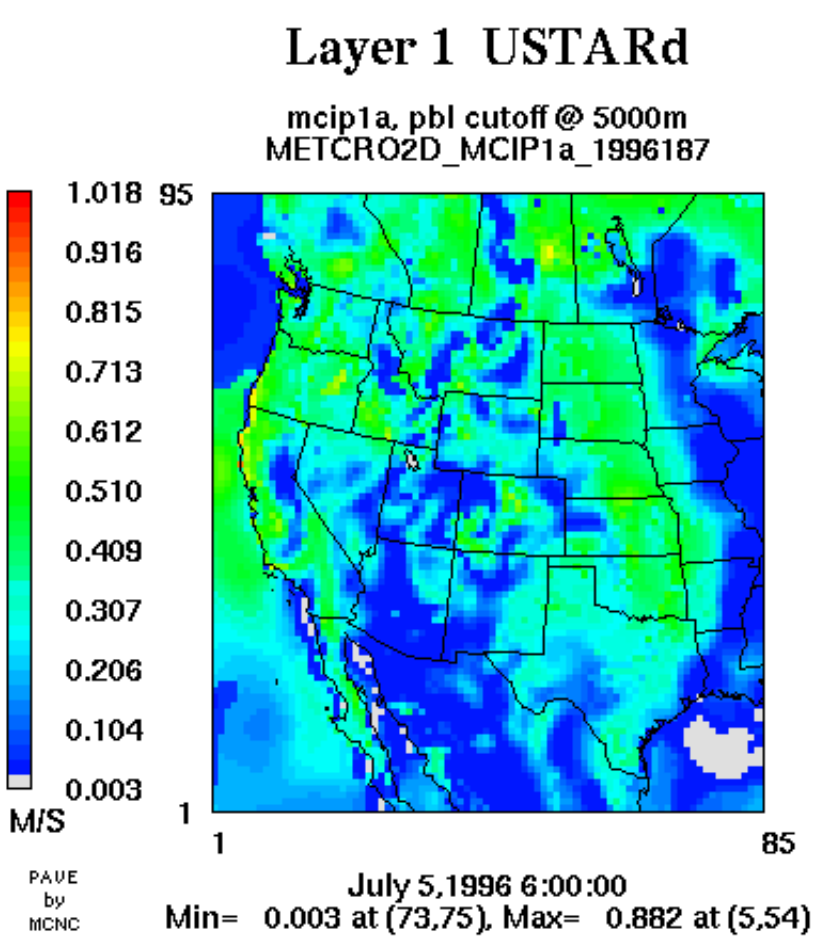
WRAP July 1996, 23 Layer, Layer 1



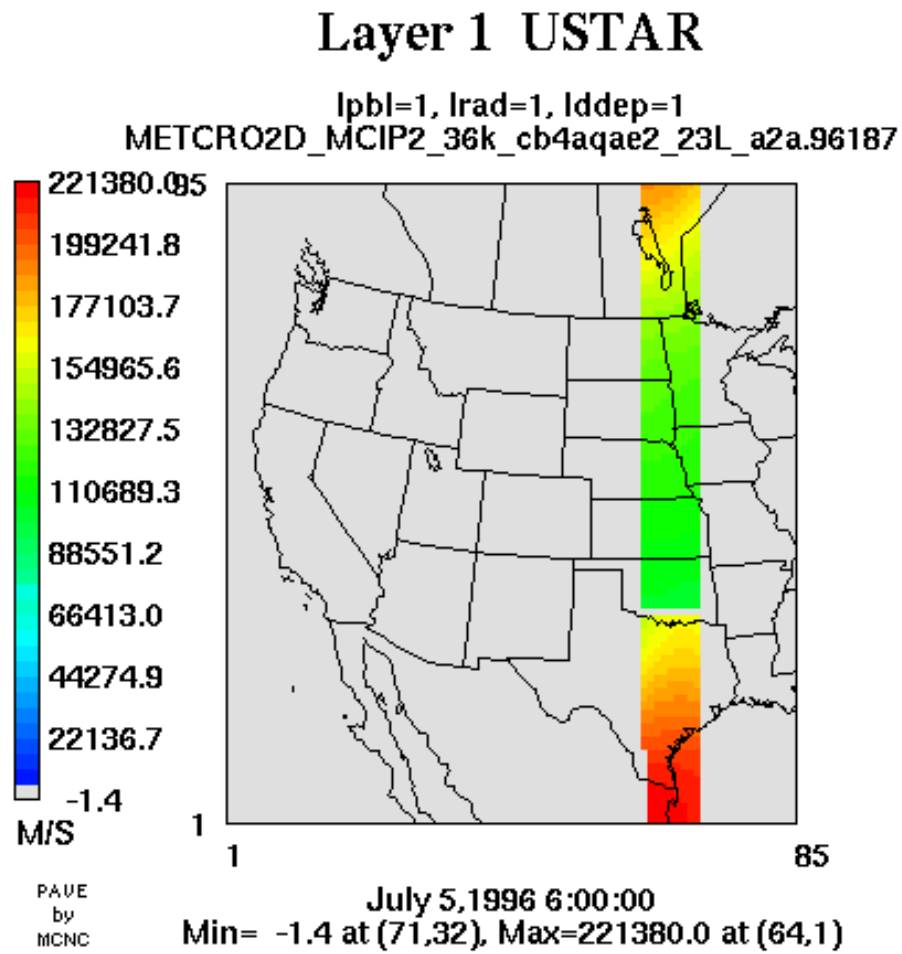
Delta ANO3: MCIP2 - MCIP1

WRAP July 1996, 23Layer, Layer 1




Layer 1 USTARd
mcip1a, pbl cutoff @ 5000m
METCRO2D_MCIP1a_1996187
1.018
0.916
0.815
0.713
0.612
0.510
0.409
0.307
0.206
0.104
0.003
M/S
95
1
1
85
PAVE by MCNC
July 5,1996 6:00:00
Min= 0.003 at (73,75), Max= 0.882 at (5,54)

MCIP1


Layer 1 USTAR
lpbl=1, lrad=1, lddep=1
METCRO2D_MCIP2_36k_cb4aqae2_23L_a2a.96187
221380.0
199241.8
177103.7
154965.6
132827.5
110689.3
88551.2
66413.0
44274.9
22136.7
-1.4
M/S
95
1
1
85
PAVE by MCNC
July 5,1996 6:00:00
Min= -1.4 at (71,32), Max=221380.0 at (64,1)

MCIP2

Summary

- Quality of MM5 outputs
- Balance between CPU cycles & disk storage vs. layer collapsing
- Direct pass through vs. rediagnosing