Topical Report

A Comparison of MM5 Model Estimates for February and July 2001 Using Alternative Input Databases

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1 INTRODUCTION

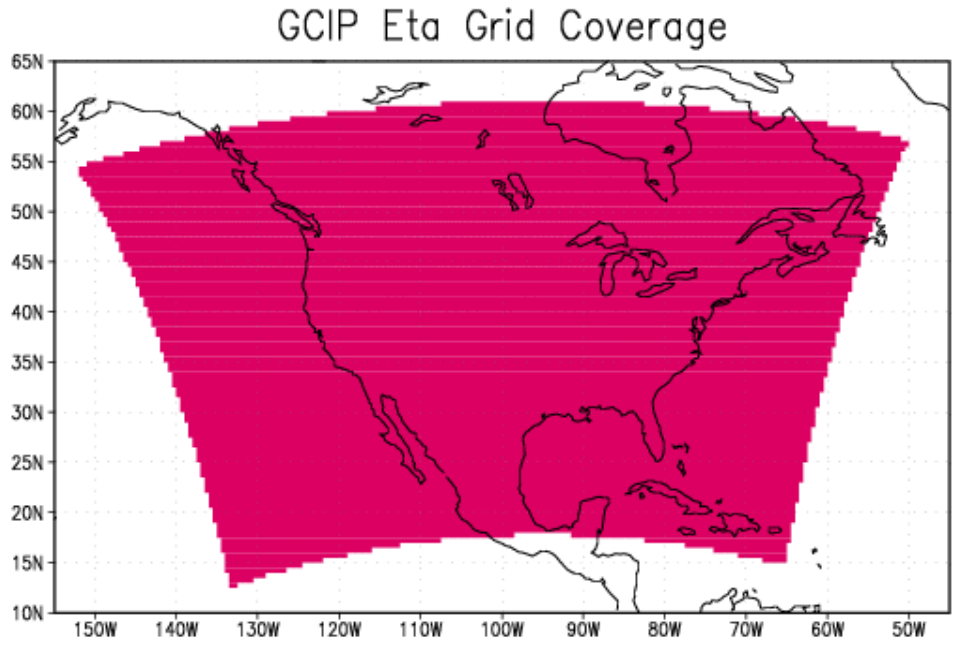
An issue that has arisen in the meteorological modeling for air quality community as to which "first guess" fields are best applied for generating input to the MM5 meteorological model. The two most appealing databases currently available are the "ETA" model archive fields, and the NCAR/NCEP Reanalysis Project (NNRP) archives.

Both archives have potential benefits both strong points and limitations. The ETA archive has the advantage of having relatively fine horizontal resolution (~40 meter), but covers a limited area. The spatial extent of the ETA archive is shown in Figure 1-1. The ETA data are also only archived at 0Z and 12Z. The NNRP dataset has a disadvantage of very coarse horizontal resolution (2.5 Degrees, ~180km), but has the advantages of global coverage, and six hourly updates.

The central issue is thus, is it advantageous to have a greater spatial coverage and more frequent updates, or to have higher spatial coverage over a more limited area with less frequent updates.

This report summarized activities performed by Alpine Geophysics in an attempt to help better understand this issue.

Figure 1-1: ETA Grid Coverage.



2 METHODOLOGY

The methodology for this approach is very straightforward. The MM5 model is applied to two three-week periods, a winter case (2001 February) and a summer case (2001 July) and the model results are compared with available observations and synoptic weather charts.

2.1 Model Selection and Application

Below we give a brief summary of the MM5 input data preparation procedures we propose for the episodic and annual modeling exercises.

Model Selection: The most recent version of the publicly available non-hydrostatic version of MM5 (version 3.5) is used. The MM5 released terrain, pregrid, little_r and interpf processor were used to develop model inputs.

Horizontal Domain Definition: The computational domains for the ETA and NNRP applications are presented in Figures 2-1 and 2-2, respectively. The ETA domain is a single 36km domain with 165 x 129 grid cells, selected to maximize the coverage of the ETA analysis region. The NNRP domain is a 108km mother domain with a 36 km nested domain. The 108 km domain has 69 x 51 grid cells. The 36 km national grid consists of 160 x 112 grid cells. We recommend using the newly agreed upon "national RPO" grid projection which has a pole of 40^0, -97^0 with true latitudes of 33^0 and 45^0.

Vertical Domain Definition: The MM5 modeling is based on 34 vertical layers with an approximately 50 meter deep surface layer. The MM5 vertical domain is presented in both sigma and height coordinates in Table 2-1.

Topographic Inputs: Topographic information for the MM5 is developed using the NCAR and the United States Geological Survey (USGS) terrain databases. The 108 and 36 km grids are based the 5 min (~9 km) Geophysical Data Center global data. Terrain data is interpolated to the model grid using a Cressman-type objective analysis scheme. To avoid interpolating elevated terrain over water, after the terrain databases are interpolated onto the MM5 grid, the NCAR graphic water body database will be used to correct elevations over water bodies.

Vegetation Type and Land Use Inputs: Vegetation type and land use information is developed using the most recently released NCAR/PSU databases provided with the MM5 distribution. The 108 and 36 km grids use the 2 min. (~ 4 km). Standard MM5 surface characteristics corresponding to each land use category will be employed.

Atmospheric Data Inputs: The focus of this study is to examine the influence the choice of "first guess" meteorological fields has on the MM5 model predictions. For the ETA

case, the first guess fields are taken from the NCAR ETA archives. For the NNRP case, the data are extracted from the ETA archives. Surface and upper-air observations used in the objective analyses, following the procedures outlined by Stauffer and Seaman at PSU, are quality-inspected by MM5 pre-processors using automated gross-error checks and "buddy" checks. In addition, rawinsonde soundings undergo vertical consistency checks. The synoptic-scale data used for this initialization (and in the analysis nudging discussed below) are obtained from the conventional National Weather Service (NWS) twice-daily radiosondes and 3-hr NWS surface observations.

Water Temperature Inputs: The NNRP and ETA database contains a "skin temperature" field. This can be used as a water temperature input to MM5. It is recognized that these skin temperatures can lead to temperature errors along coastlines. However, for this sort of analysis focusing on bulk continental scale transport, this issue is like not important.

FDDA Data Assimilation: This simulation uses an analysis-nudging technique were the observations are nudged toward a field prepared by objective analyzing surface and aloft monitor data into the first-guess fields. For these simulations a nudging coefficient of 2.5×10^{-4} was used for winds and temperature and 1×10^{-5} for mixing ratio. Only 3D analysis nudging was performed and thermodynamic variables are not nudged within the boundary layer.

Physics Options: The MM5 model physics options in these simulations are as follows:

Kain-Frisch Cumulus Parameterization
Blakadar PBL Scheme
Simple Ice Moisture Scheme
RRTM Atmospheric Radiation Scheme
Multi-layer Soil Temperature Model

2.2 Evaluation Approach

The model evaluation approach is based on a combination of qualitative and quantitative analyses. The qualitative approach is to compare the model estimated sea level pressure and radar reflectivity fields with observed values from historical weather chart archives. The statistical approach is to examine the model bias and error for temperature, mixing ratio and the Index of Agreement for the windfields.

Interpretation of bulk statistics over a continental scale domain is problematic. It is difficult to detect if the model is missing important sub-regional features. For this analysis the statistics are performed on a state by state basis, a Regional Planning Organization (RPO) basis, and on a domainwide basis.

The observed database used in this analysis is the NOAA Techniques Development Lab (TDL) Surface Hourly Observation database obtained from the NCAR archives.

Table 2-1: MM5 Vertical Domain Specification.

k(MM5)	sigma	press.(mb)	height(m)	depth(m)
34	0.000	10000	15674	2004
33	0.050	14500	13670	1585
32	0.100	19000	12085	1321
31	0.150	23500	10764	1139
30	0.200	28000	9625	1004
29	0.250	32500	8621	900
28	0.300	37000	7720	817
27	0.350	41500	6903	750
26	0.400	46000	6153	693
25	0.450	50500	5461	645
24	0.500	55000	4816	604
23	0.550	59500	4212	568
22	0.600	64000	3644	536
21	0.650	68500	3108	508
20	0.700	73000	2600	388
19	0.740	76600	2212	282
18	0.770	79300	1930	274
17	0.800	82000	1657	178
16	0.820	83800	1478	175
15	0.840	85600	1303	172
14	0.860	87400	1130	169
13	0.880	89200	961	167
12	0.900	91000	794	82
11	0.910	91900	712	82
10	0.920	92800	631	81
9	0.930	93700	550	80
8	0.940	94600	469	80
7	0.950	95500	389	79
6	0.960	96400	310	78
5	0.970	97300	232	78
4	0.980	98200	154	39
3	0.985	98650	115	39
2	0.990	99100	77	38
1	0.995	99550	38	38
0	1.000	100000	0	0

Figure 2-1: National NNRP Computational Domain.

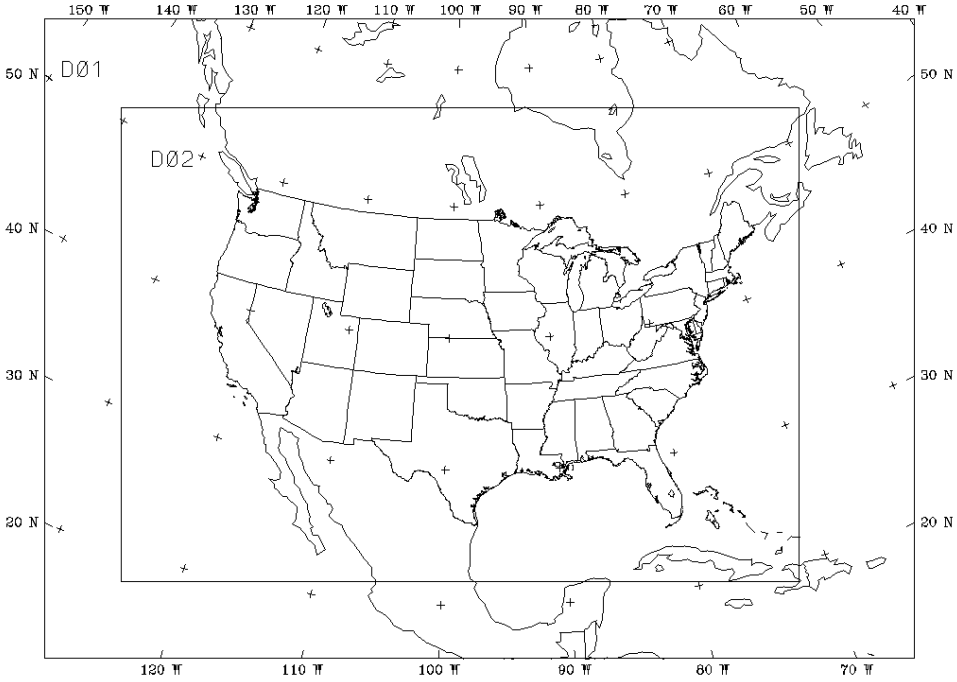
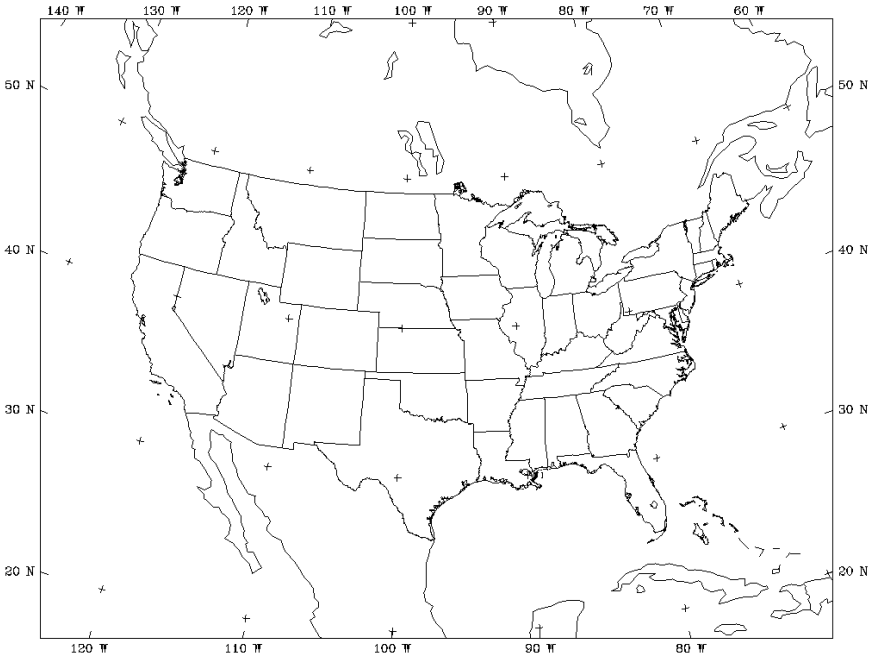


Figure 2-2: National ETA Computaional Grid.



3 RESULTS

3.1 Model Resource Requirements

The model resource requirements for the two computational domains are presented in Table 3-1. The larger 36km ETA domain takes about 12% longer to run, and produces output files that are approximately the same size.

3.2 Model Evaluation Results

The synoptic and statistical evaluations for the two episodes using the two difference model configuration options are presented in the following sections.

3.2.1 Synoptic Evaluation

One very important metric of model performance is to qualitatively assess whether how well the model is able to capture the evolution of synoptic systems. Sea level pressure and radar reflectivity plots for the February episode for both the ETA and NNRP simulations are presented in Figure 3.1. One each page, the first column presents the archived surface chart from weather.Unisys.com. The second column presents the plots for the ETA simulation and the third column are plots for the NNRP simulation. On the ETA and NNRP simulation, the model estimate sea-level pressure is the blue line. Shaded areas on both the model estimated and analyzed charts denote regions of high radar reflectivity.

Surface synoptic style charts every 48 hours through the February episode are presented in Figures 3-1 through 3-12. Synoptic charts for the July episode are presented in Figures 3-13 through 2-24. Some general conclusions from these figures are:

> The NNRP configuration tends to produce larger regions of radar reflectivity than the ETA configuration. The NNRP regions agree more closely with observations. Both configurations underestimate the extent of the regions of high radar reflectivity, particularly for the July episode.
>
> Both models generally capture long wave patterns. Neither configuration has a tendency to either lag systems behind the observations, or to advance systems faster than suggested by the observations.

3.2.2 Statistical Evaluation

The results for the statistical evaluation are presented in this section. The tables present the statistical metric for each state, for each Regional Planning Organization, and for the

entire modeling domain (including only the United States and Canada). For all tables, the model configuration that most closely replicates the observed values is shaded blue. In all figures, a state is shaded blue if the ETA configuration statistic is better and white if the NNRP configuration statistic is better.

Bias scores for the two MM5 model applications averaged over the February episode are presented in Table 3-2. A graphical depiction of Table 3-2 is presented in Figure 3-25. The ETA configuration is superior for the majority of the states, except for the Pacific coast and along the Mississippi River. For the nation as a whole, the NNRP configuration has a lower temperature bias. Bias error data are presented in Table 3-3 and Figure 3-25. The ETA configuration temperature bias is lower for all states, and for the country as a whole.

Mixing ratio bias data is presented in Tables 3-4 and Figure 3-37. The ETA configuration has a lower bias averaged over the entire country, but on a state-by-state basis, the configurations split the nation fairly evenly with the ETA configuration doing better in the Northern states and the NNRP configuration doing better in the southern states. Mixing ratio error is presented in Tables 3-5 and Figures 3-38. Again, for the country as a whole, the ETA configuration is superior. On a statewise basis, the ETA configuration is superior except for the southereastern states, New Mexico and Arizona.

Temperature bias for the July episode are presented in Table 3-6 and Figure 3-29. Averaged over the country, the ETA model appears superior. Statewise, the ETA is superior except in the Midwest, Georgia and the Carolinas. As was seen in the February episode, Table 3-7 and Figure 3-30 show the ETA configuration is superior for temperature error for every state and region.

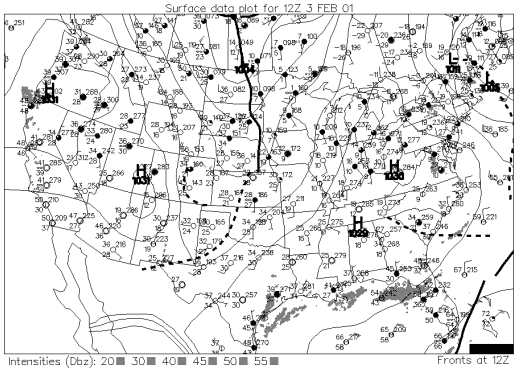
Mixing ratio bias is presented in Table 3-8 and Figure 3-31. Averaged over the United States and Canada, the ETA configuration has lower overall error. On a state by state basis, the ETA is generally better in the Midwest, northern states and Kansas, Oklahoma, Texas and New Mexico. Mixing ratio error is presented in Table 3-9 and Figure 3-32. The ETA configuration is better on a domain-wide basis, and is better in the Northern states and Oklahoma.

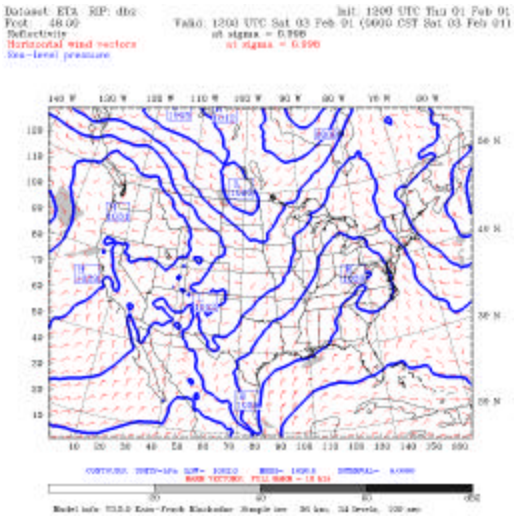
Wind comparison index of agreement for the February episode are presented in Table 3-9 and Figure 3-33. The ETA configuration has a higher index agreement for every state and for the entire domain. The July data are presented in Table 3-10 and Figure 3-34. Again, the ETA configuration is superior except for 10 states across the country.

Table 3-1: MM5 model computational requirements per 5.5 day simulation. CPU times are on a dual 1GHz P-III computer system running Linux and the Portland Group FORTRAN compiler.

Model Configuration	Memory Requirements	CPU Time Per Block	Model Output Disk Size
ETA	141 Mbytes	19.2 Hours	4.5 Gbytes
NNRP	230 Mbytes	16.8 Hours	4.5 Gbytes

Figure 3-1: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 3 Feb. 2002.





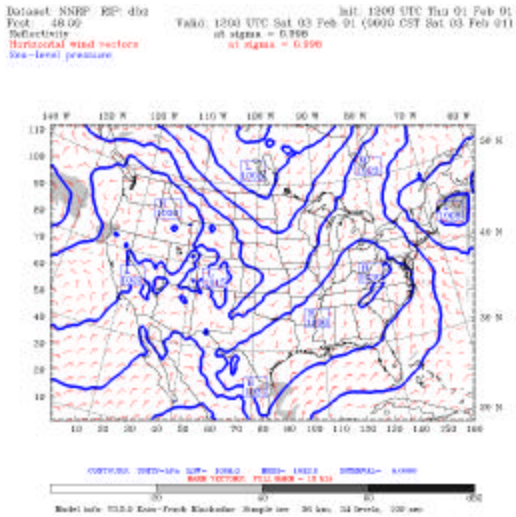
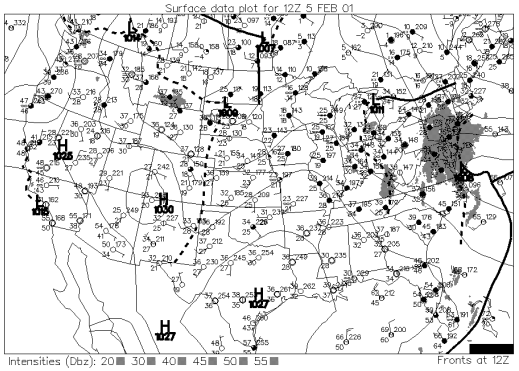
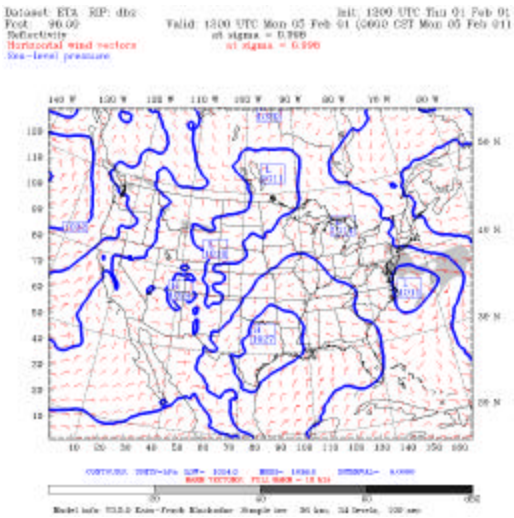


Figure 3-2: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 5 Feb. 2002.





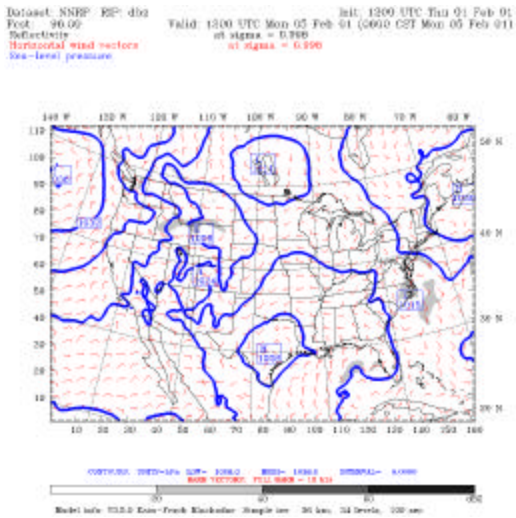
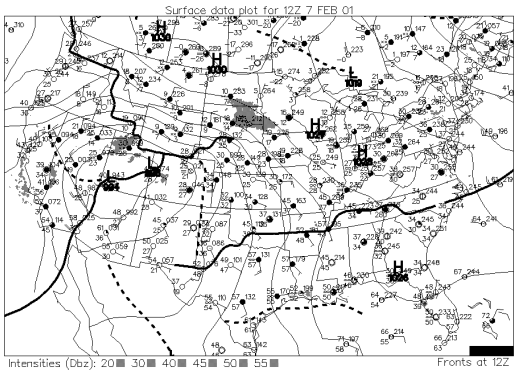
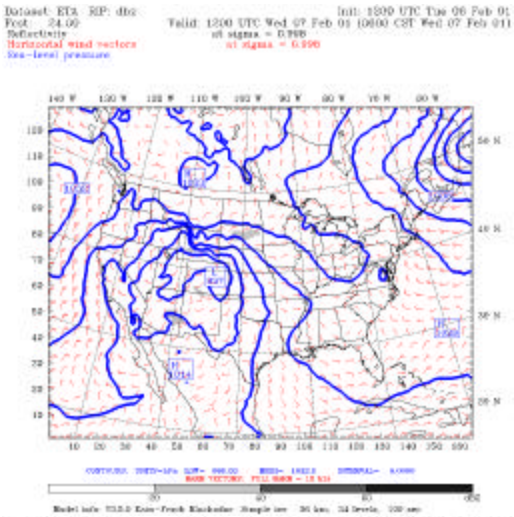


Figure 3-3: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 7 Feb. 2002.





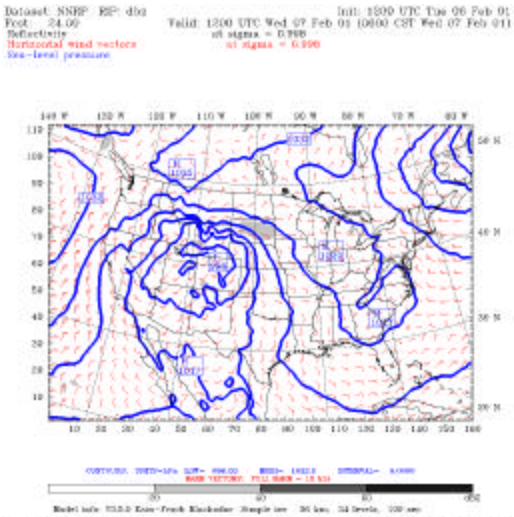
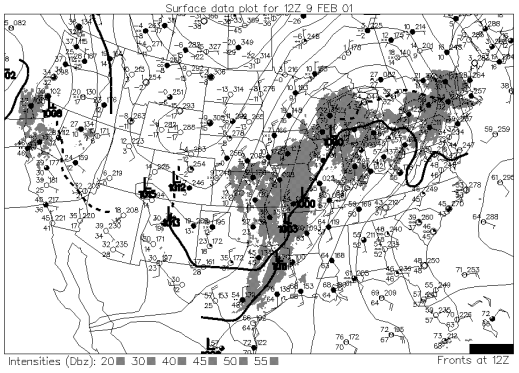
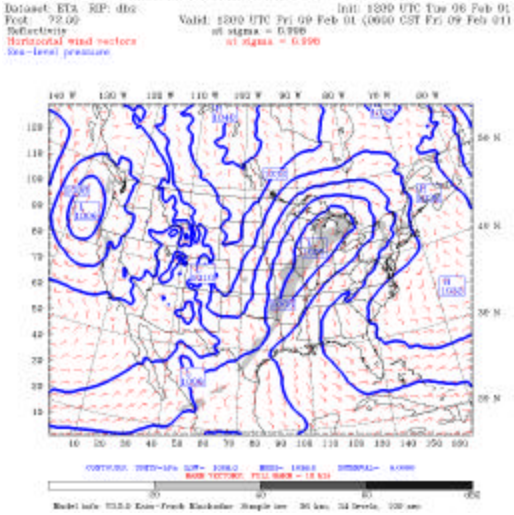


Figure 3-4: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 9 Feb. 2002.





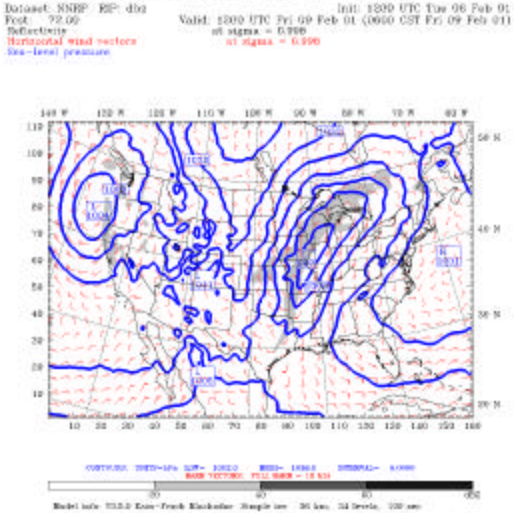
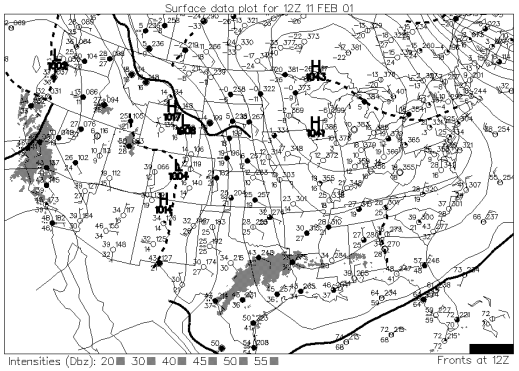
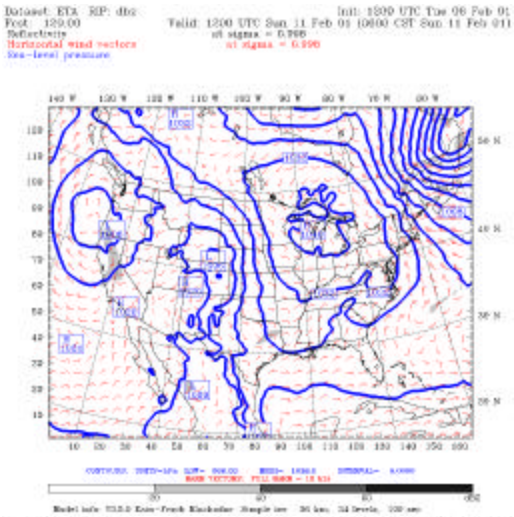


Figure 3-5: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 11 Feb. 2002.





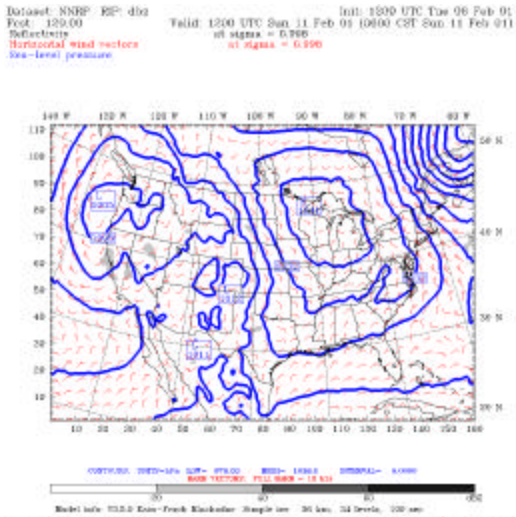
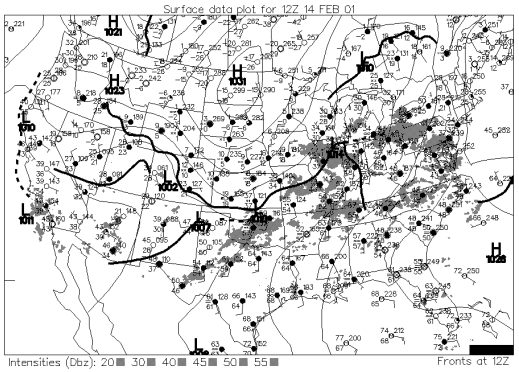
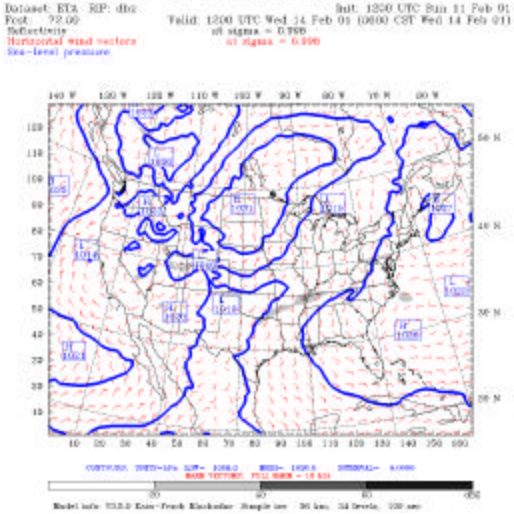


Figure 3-6: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 14 Feb. 2002.





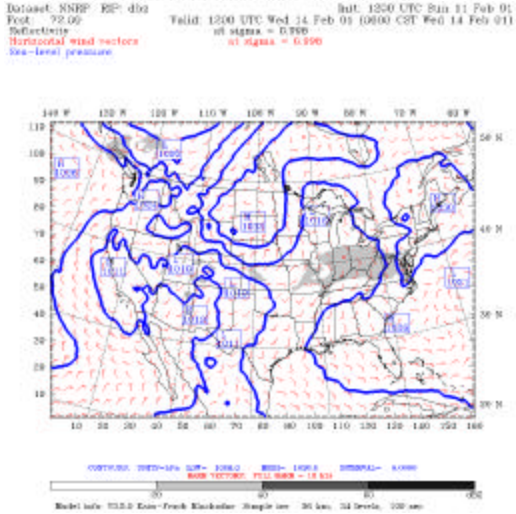
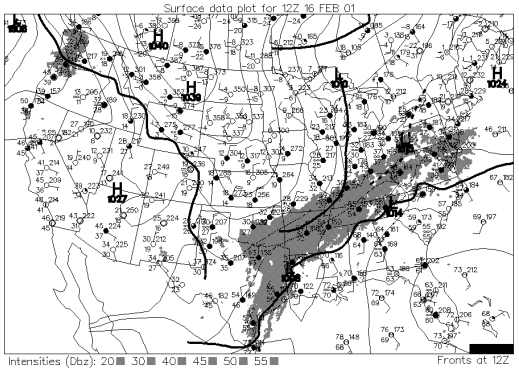
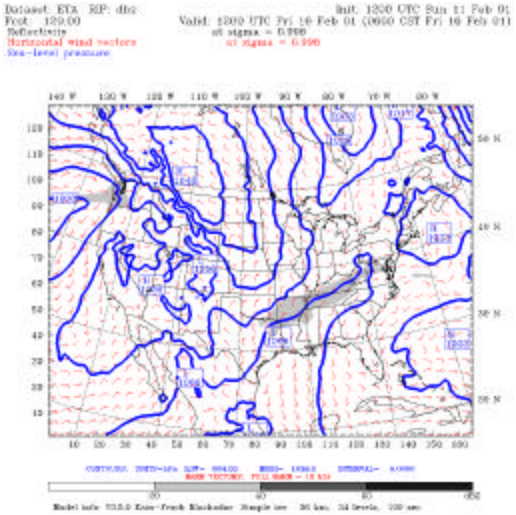


Figure 3-7: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 16 Feb. 2002.





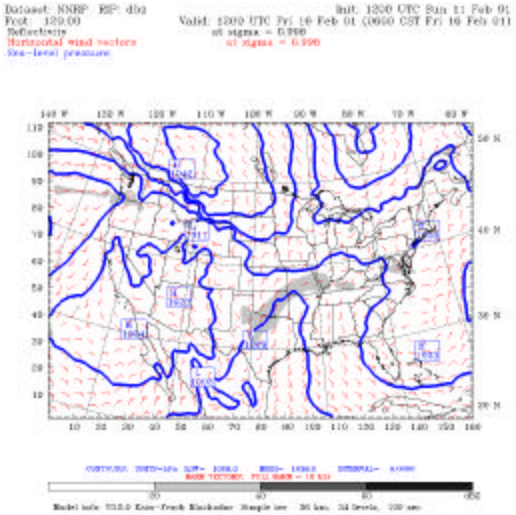
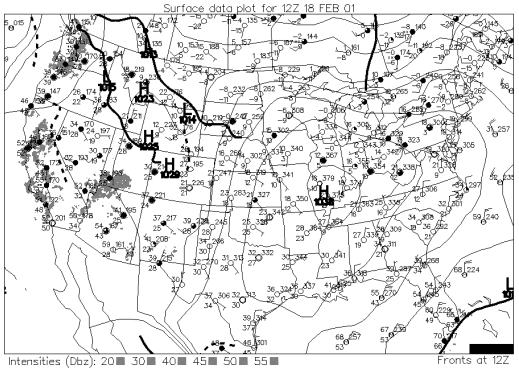
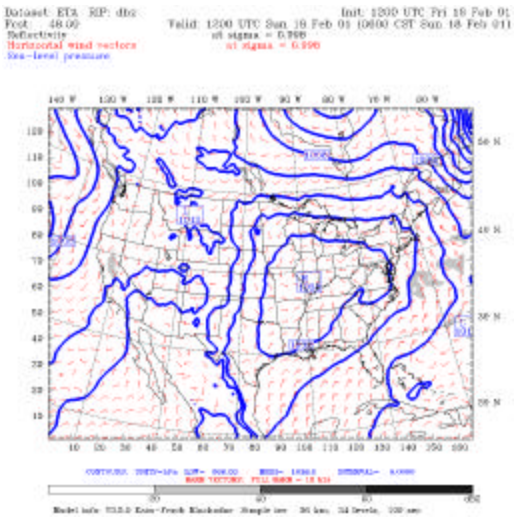


Figure 3-8: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 18 Feb. 2002.





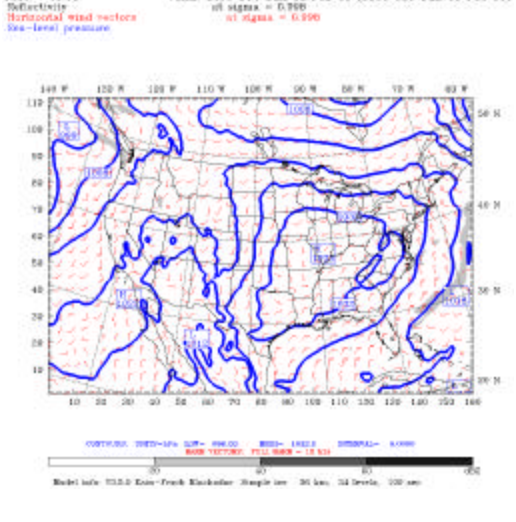
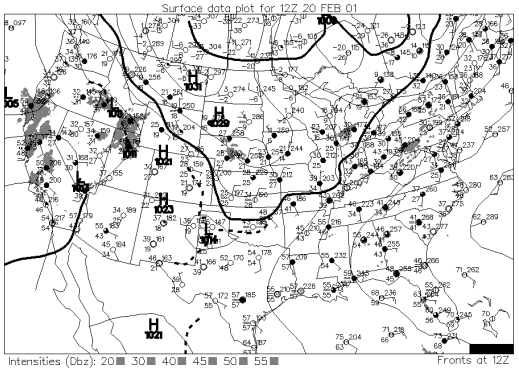
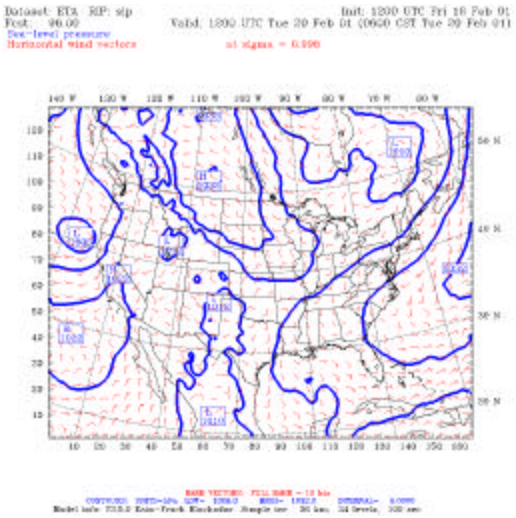


Figure 3-9: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 20 Feb. 2002.





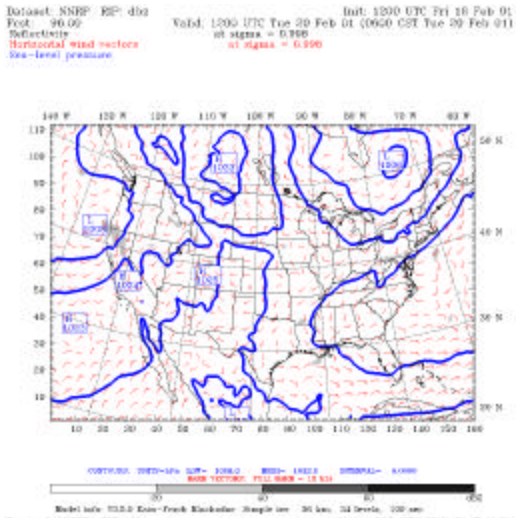
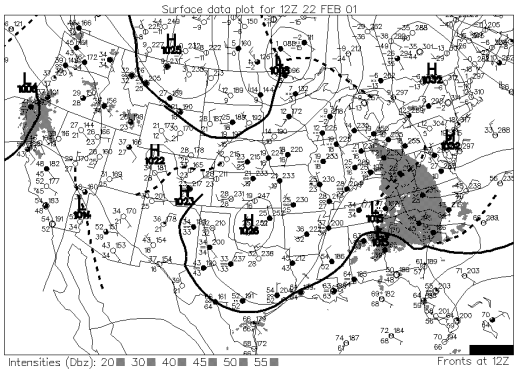
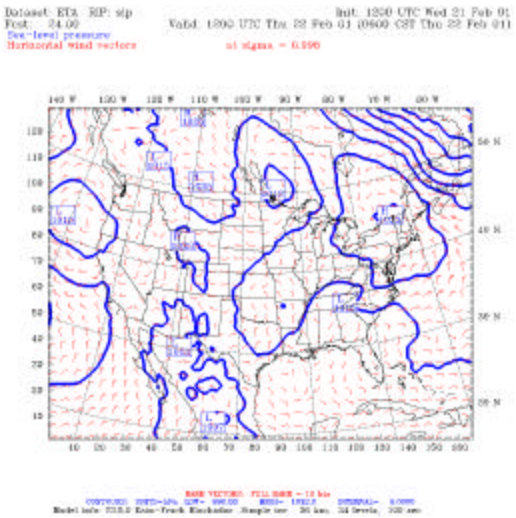


Figure 3-10: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 22 Feb. 2002.





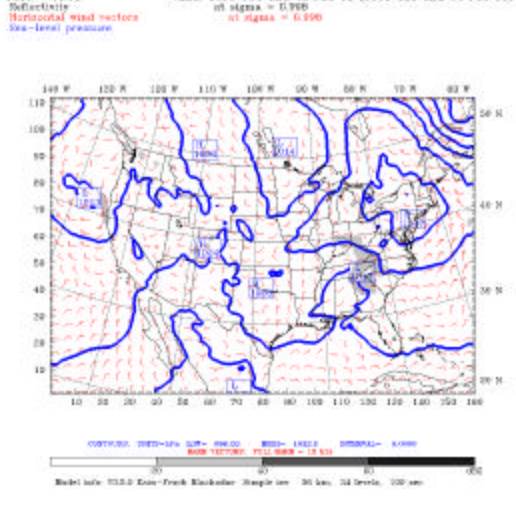


Figure 3-11: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 24 Feb. 2002.

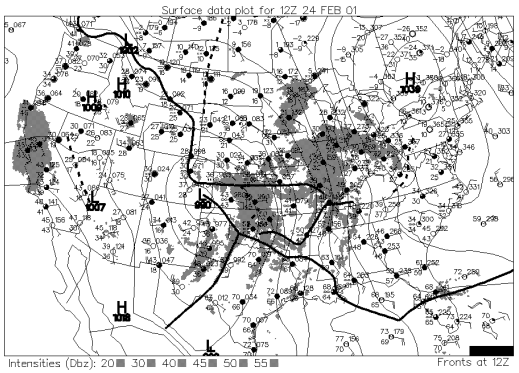
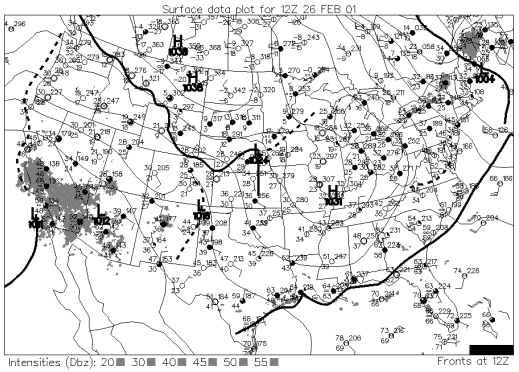


Figure 3-12: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 26 Feb. 2002.



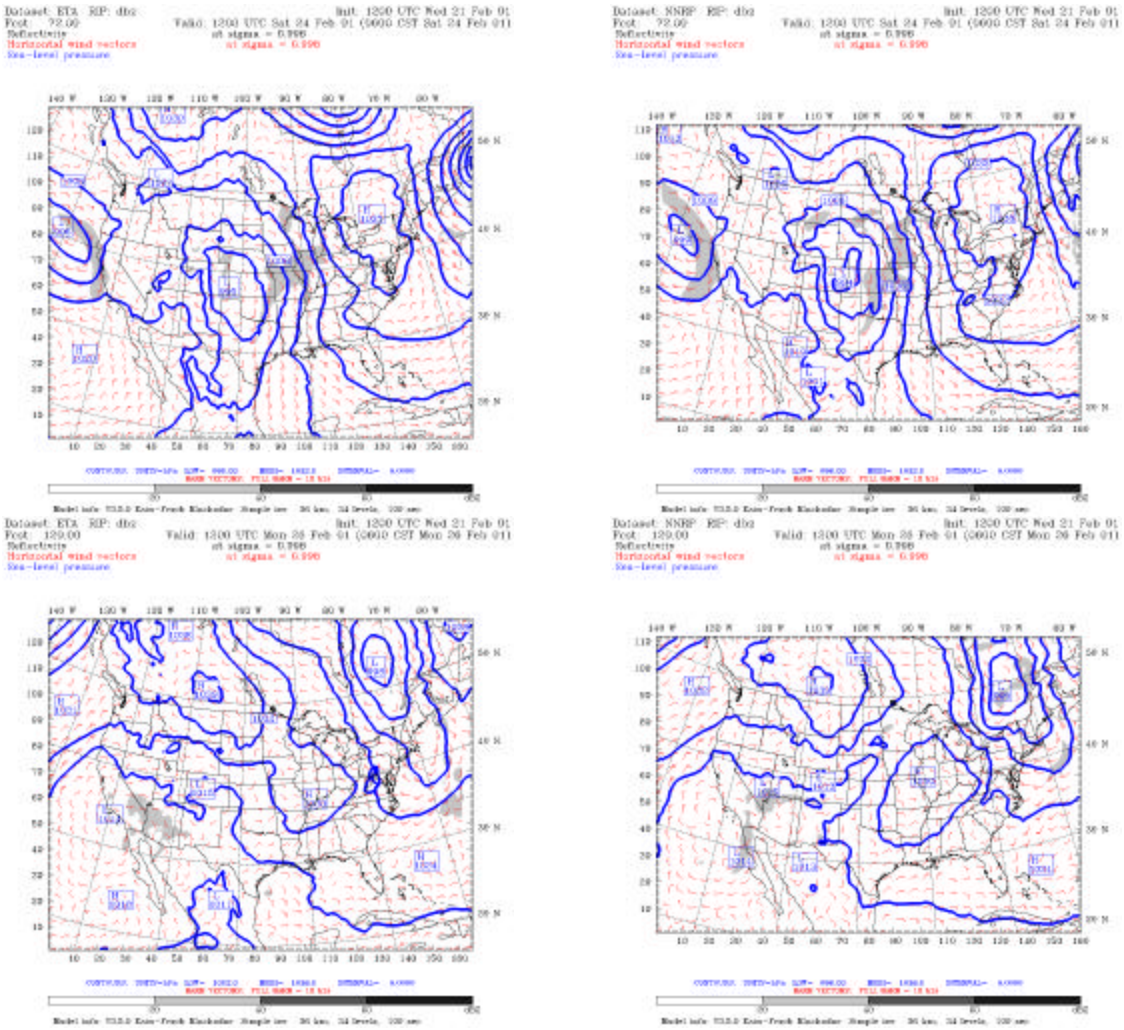
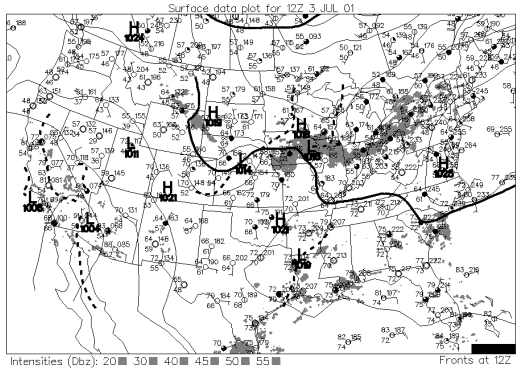
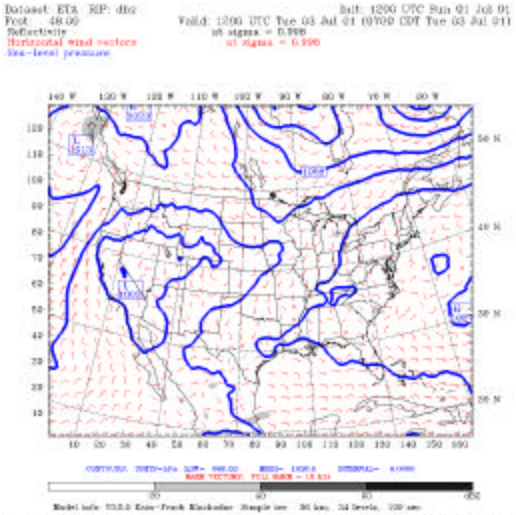


Figure 3-13: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 3 July 2002.





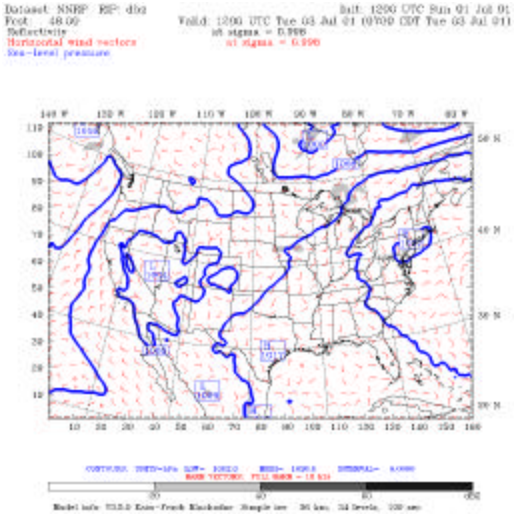
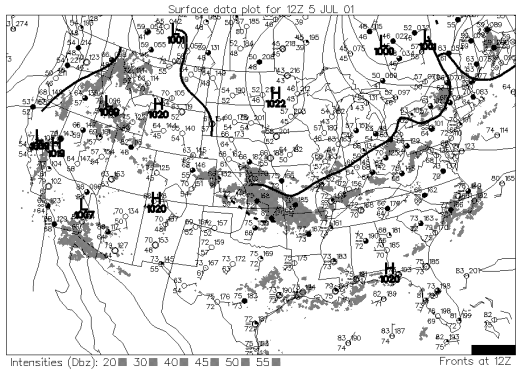
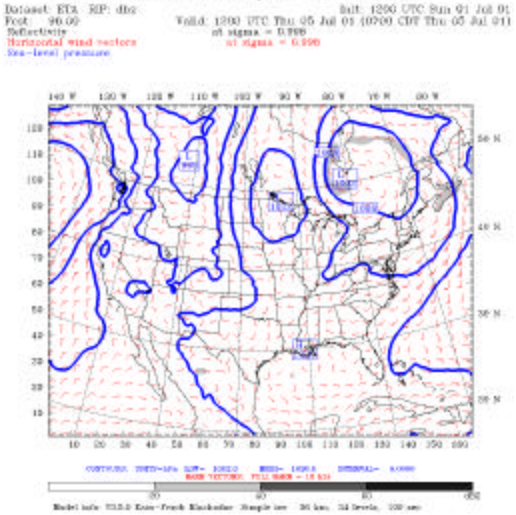


Figure 3-14: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 5 July 2002.





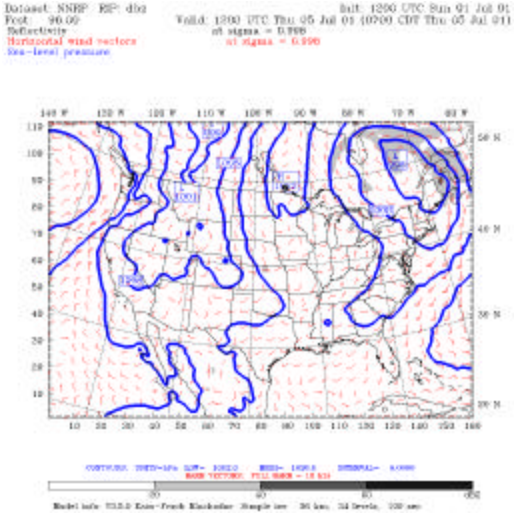
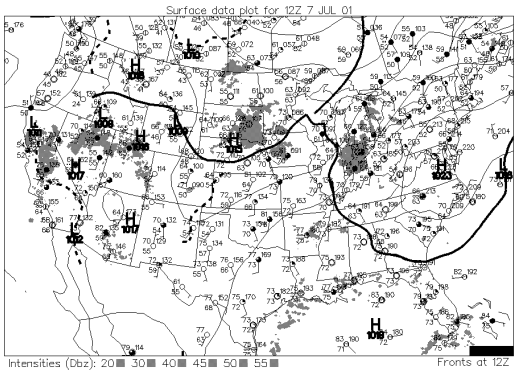
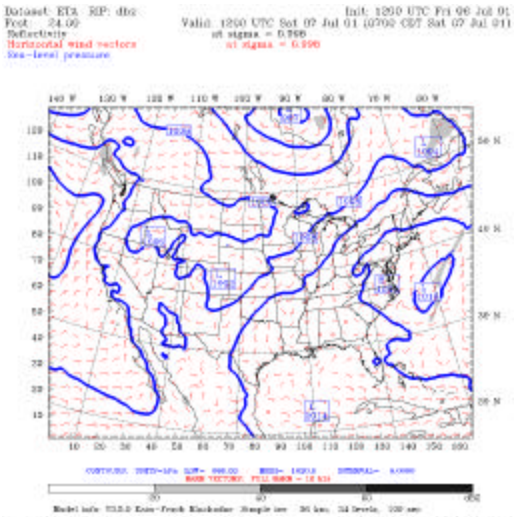


Figure 3-15: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 7 July 2002.





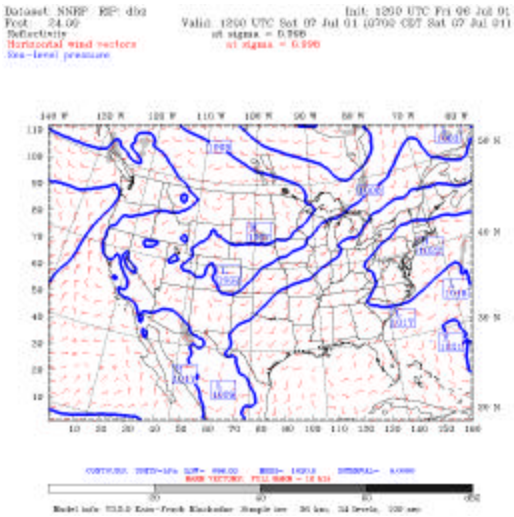
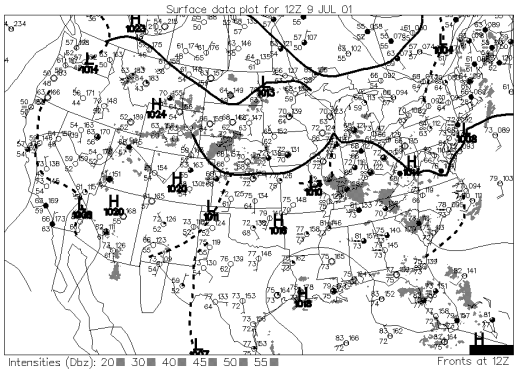
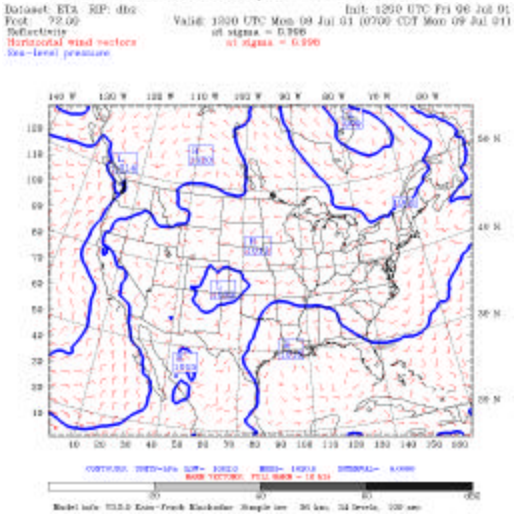


Figure 3-16: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 9 July 2002.





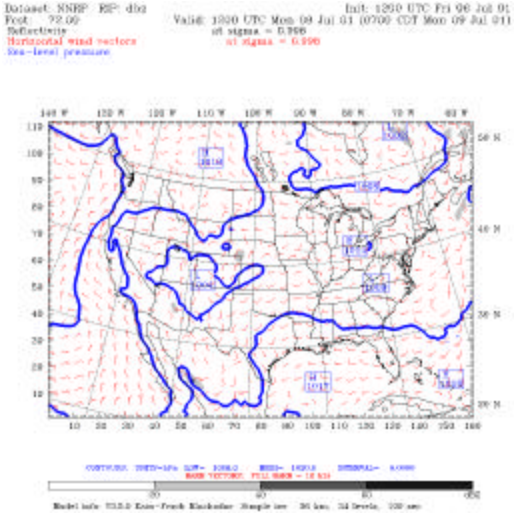
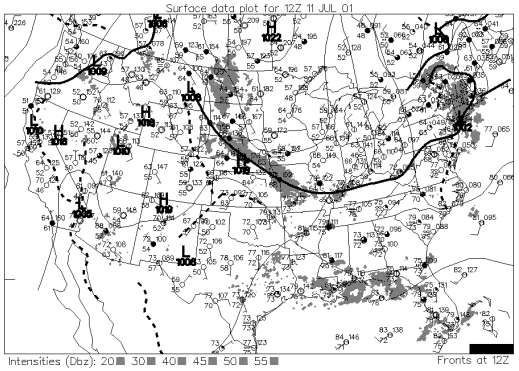
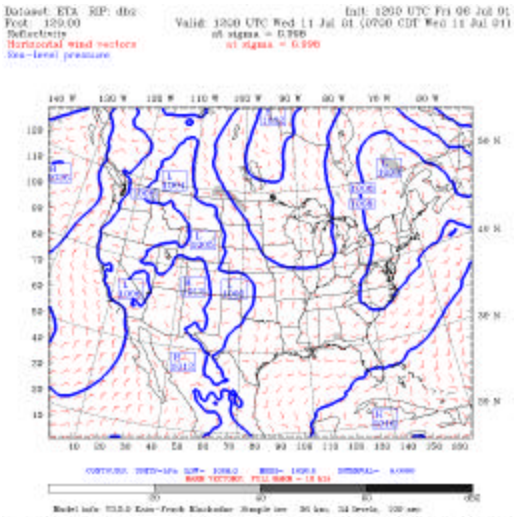


Figure 3-17: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 11 July 2002.





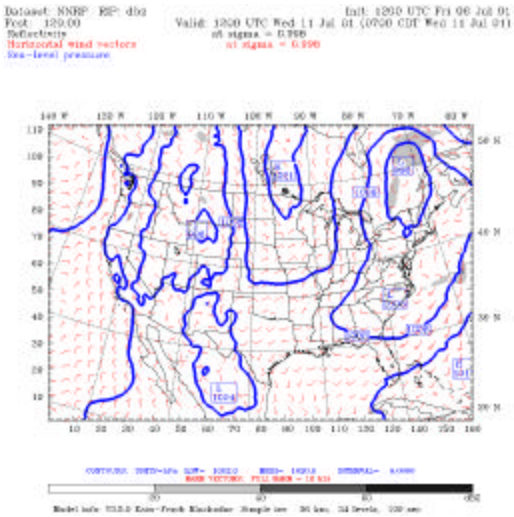
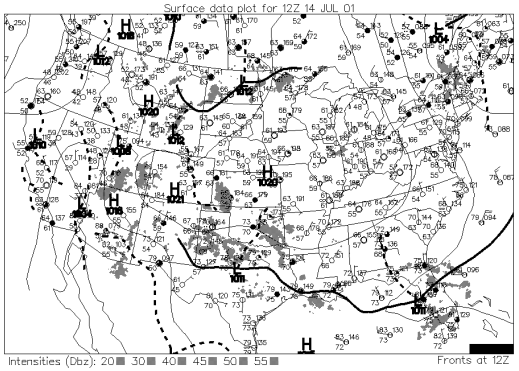
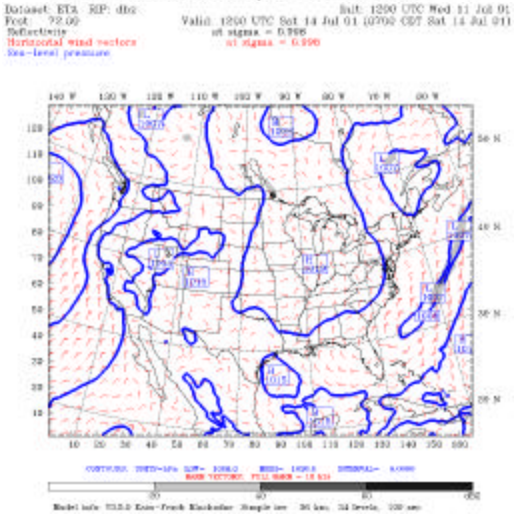


Figure 3-18: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 14 July 2002.





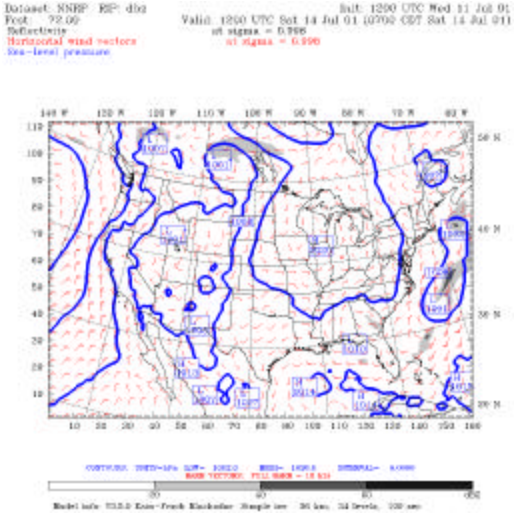
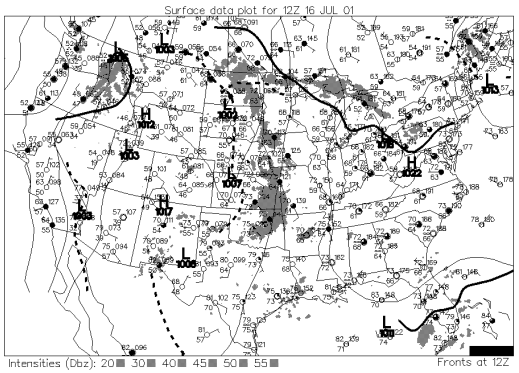
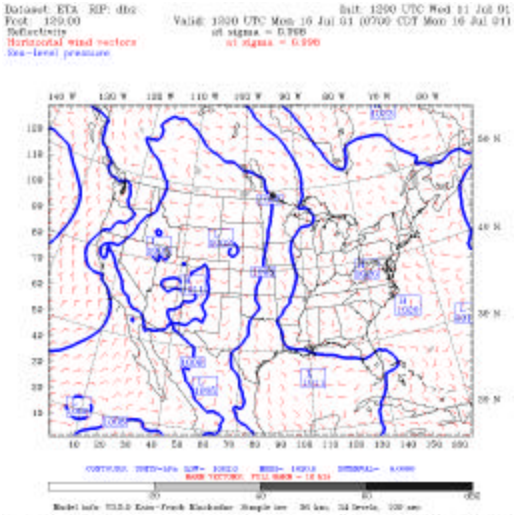


Figure 3-19: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 16 July 2002.





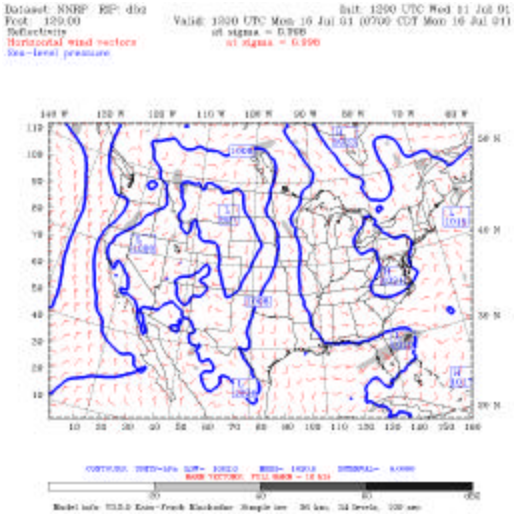
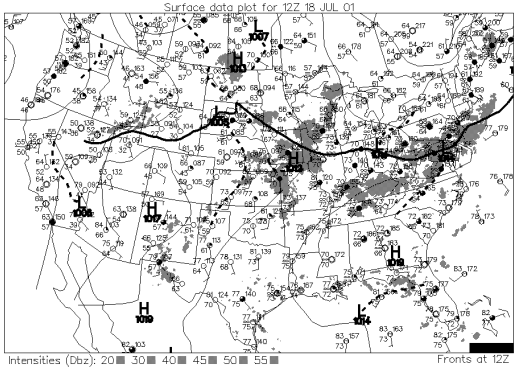
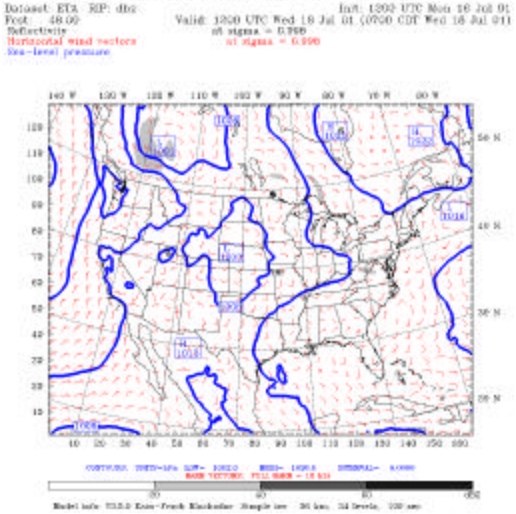


Figure 3-20: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 18 July 2002.





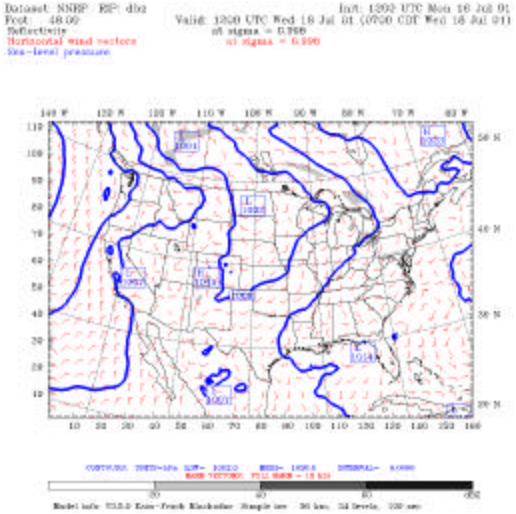
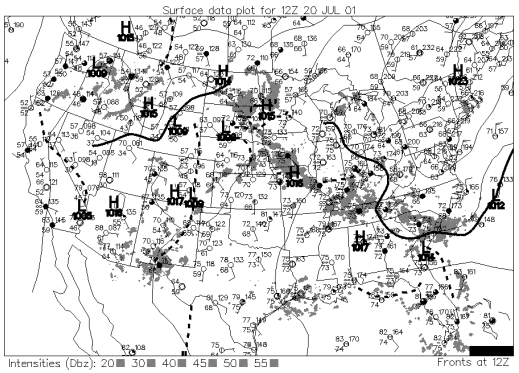
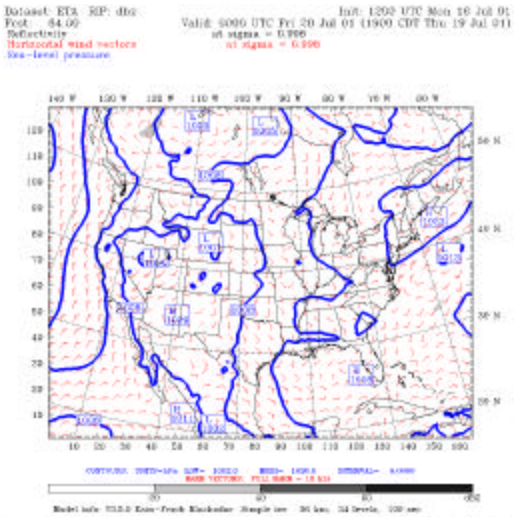


Figure 3-21: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 20 July 2002.





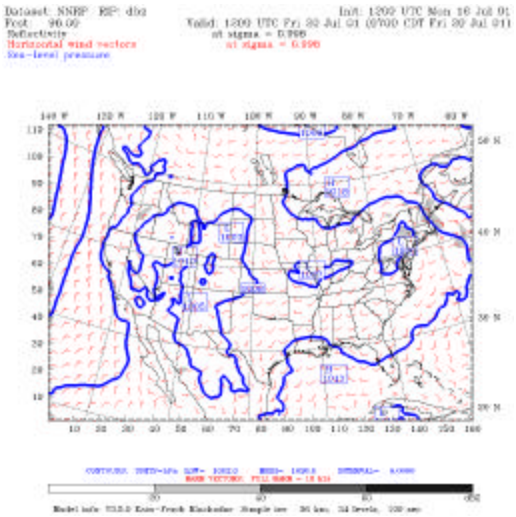
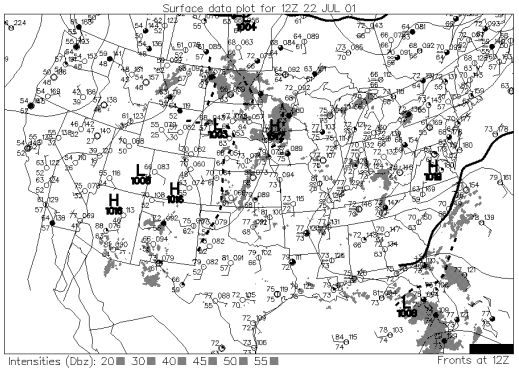
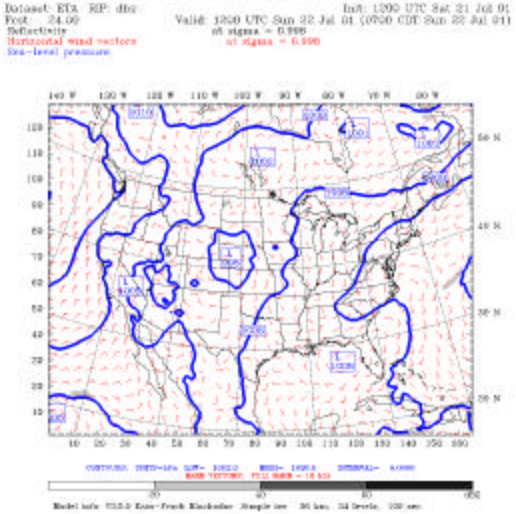


Figure 3-22: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 22 July 2002.





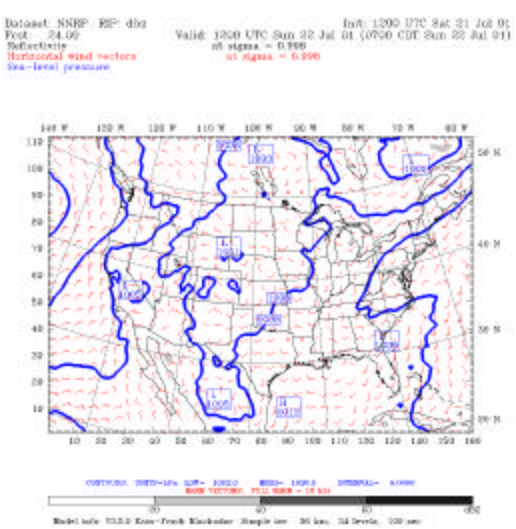
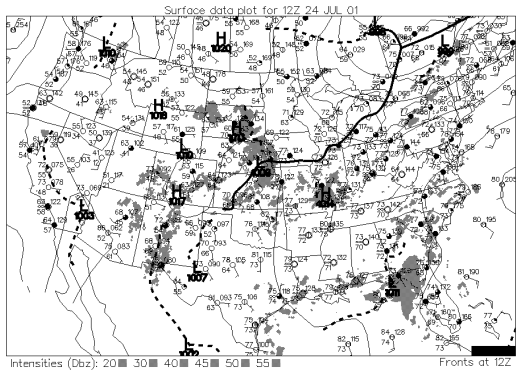
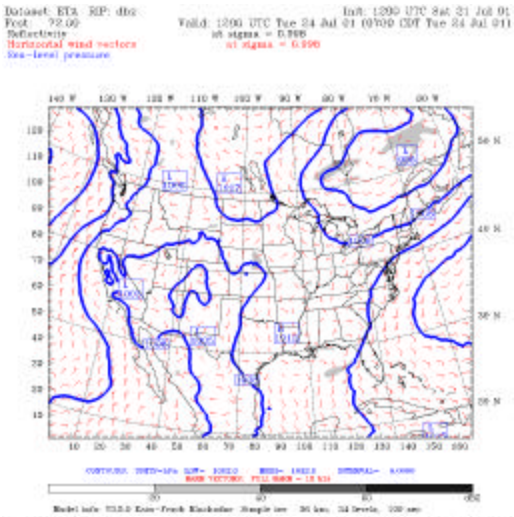


Figure 3-23: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 24 July 2002.





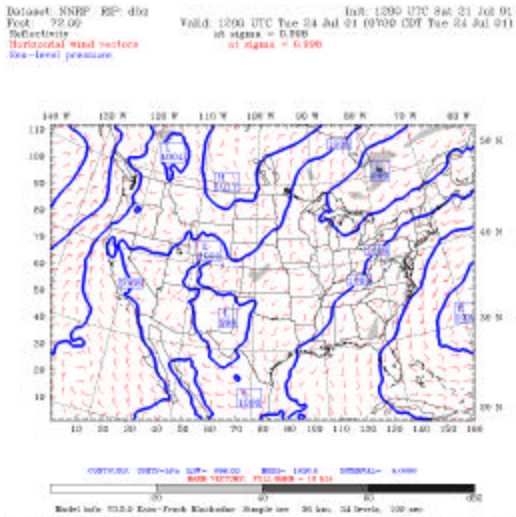
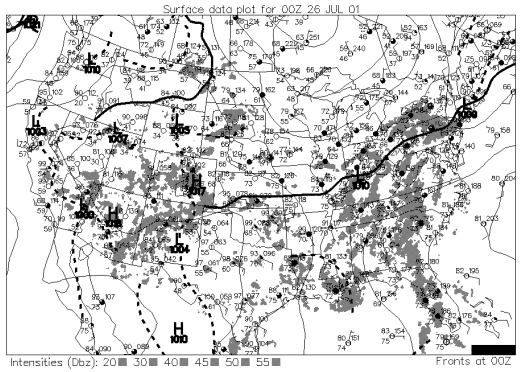
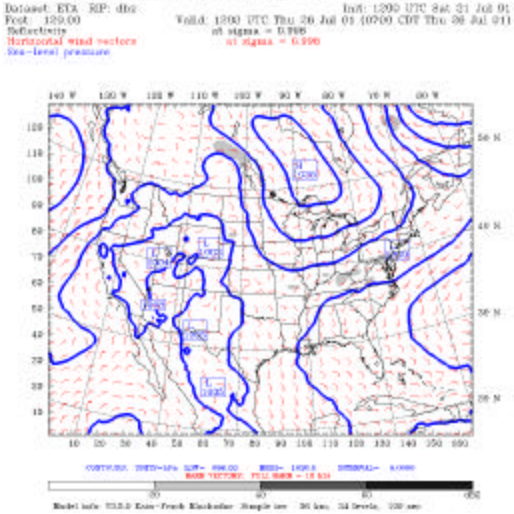


Figure 3-24: Analyzed, ETA simulation estimated and NNRP simulation estimated surface synoptic charts at 12 Z 26 July 2002.





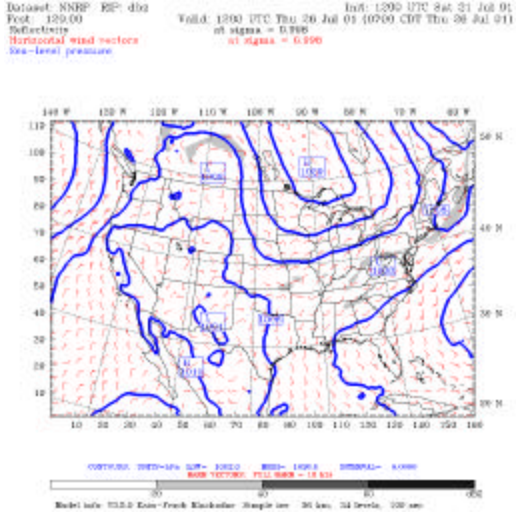


Table 3-2: Temperature Bias for ETA and NNRP MM5 Simulations of 2001 February 2-26. Regions where the ETA model is better are shaded blue.

State	ETA Bias (K)	NNRP Bias (K)
AL	-0.87	-0.97
AK	-1.13	
AZ	-0.86	-1.26
AR	-0.41	-0.34
CA	-0.84	-0.83
CO	-0.27	0.76
CT	-0.41	-0.55
DE	-0.57	-1.54
DC	-1.72	-2.70
FL	-1.37	-1.42
GA	-0.91	-1.36
ID	-0.17	1.20
IL	-0.40	-0.33
IN	-0.56	-1.14
IA	0.27	2.55
KS	0.31	2.41
KY	-0.84	-1.44
LA	-0.86	-0.50
ME	-0.51	-0.07
MD	-0.69	-1.55
MA	-0.66	-0.52
MI	-0.59	-1.08
MN	0.41	2.17
MS	-0.69	-0.63
MO	-0.33	0.29
MT	0.49	2.07
NE	0.75	3.04
NV	-1.40	-1.21
NH	0.01	0.35
NJ	-0.91	-1.42
NM	-0.62	-0.37
NY	-0.58	-1.01
NC	-0.76	-1.66
ND	0.76	2.92
OH	-1.03	-1.86
OK	-0.01	0.77
OR	-0.65	-0.17
PA	-1.09	-1.75
RI	-0.44	-0.71
SC	-0.86	-1.51
SD	1.50	3.99
TN	-0.87	-1.19
TX	-0.52	-0.85
UT	-0.60	-0.21
VT	-0.94	-0.47
VA	-1.06	-2.02
WA	-0.34	0.24
WV	-1.12	-2.08
WI	-0.64	0.51
WY	1.15	2.54
CENRAP	-0.01	1.07
MANE-VU	-0.68	-0.91
MW RPO	-0.65	-0.71
VISTAS	-0.99	-1.50
WRAP	-0.33	0.34
DOMAIN	-0.46	-0.12

Figure 3-25: Temperature Bias for ETA and NNRP MM5 Simulations of 2001 February 2-26. Regions where the ETA model is better are shaded blue.

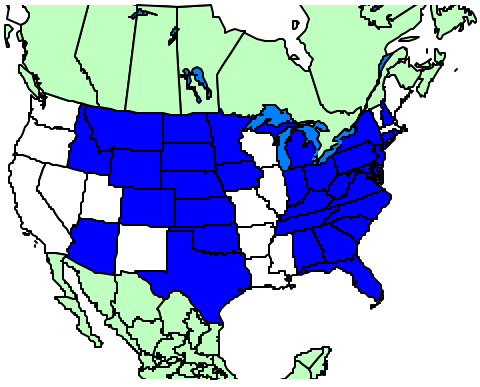


Table 3-3: Temperature Error for ETA and NNRP MM5 Simulations of 2001 February 2-26. Regions where the ETA model is better are shaded blue.

State	ETA Error (K)	NNRP Error (K)
AL	2.04	2.51
AK	1.78	
AZ	2.35	3.07
AR	1.84	2.39
CA	2.16	2.52
CO	3.08	3.66
CT	1.47	1.94
DE	2.06	2.64
DC	2.31	3.02
FL	2.47	2.87
GA	2.21	2.88
ID	2.40	2.92
IL	1.65	2.11
IN	1.63	2.11
IA	2.29	3.23
KS	2.01	3.20
KY	1.76	2.36
LA	2.33	2.55
ME	1.91	2.52
MD	2.00	2.62
MA	1.75	2.05
MI	1.71	2.33
MN	2.36	3.24
MS	2.05	2.41
MO	1.90	2.45
MT	2.85	3.55
NE	2.27	3.49
NV	2.64	3.25
NH	2.43	2.88
NJ	1.81	2.38
NM	2.45	2.91
NY	1.74	2.31
NC	2.23	2.87
ND	2.10	3.28
OH	1.77	2.41
OK	1.93	2.59
OR	2.02	2.43
PA	2.00	2.45
RI	1.33	1.68
SC	2.18	2.87
SD	2.68	4.33
TN	1.87	2.49
TX	1.87	2.56
UT	2.40	2.76
VT	2.01	2.33
VA	2.30	2.99
WA	1.82	2.30
WV	2.16	2.89
WI	2.01	2.34
WY	2.96	3.74
CENRAP	2.11	2.91
MANE-VU	1.87	2.35
MW RPO	1.78	2.30
VISTAS	2.22	2.79
WRAP	2.37	2.96
DOMAIN	2.13	2.75

Figure 3-26: Temperature Error for ETA and NNRP MM5 Simulations of 2001 February 2-26. Regions where the ETA model is better are shaded blue.

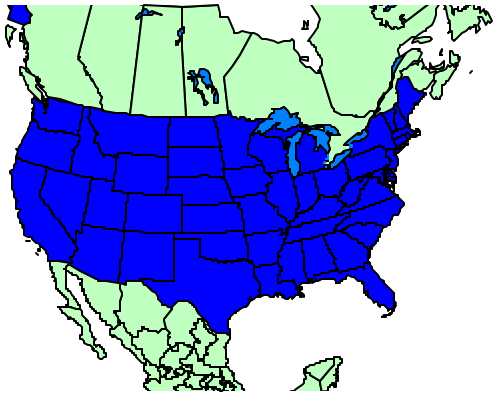


Table 3-4: Mixing Ratio Bias (g/kg) for ETA and NNRP MM5 Simulations of 2001 February 2-26. Regions were the ETA model is better are shaded blue.

State	ETA Bias (g/kg)	NNRP Bias (g/kg)
AL	0.61	0.42
AK	0.09	
AZ	0.40	0.14
AR	0.53	0.52
CA	0.25	0.16
CO	0.01	0.15
CT	0.33	0.31
DE	0.32	0.10
DC	-0.02	-0.37
FL	0.63	0.52
GA	0.51	0.23
ID	-0.11	0.14
IL	0.12	0.16
IN	0.03	-0.10
IA	0.10	0.55
KS	0.06	0.46
KY	0.47	0.31
LA	0.39	0.32
ME	0.15	0.24
MD	0.42	0.11
MA	0.29	0.34
MI	-0.01	-0.06
MN	0.03	0.26
MS	0.56	0.44
MO	0.22	0.41
MT	0.16	0.39
NE	0.10	0.49
NV	0.08	0.26
NH	0.24	0.30
NJ	0.27	0.15
NM	0.44	0.24
NY	0.20	0.12
NC	0.64	0.16
ND	0.03	0.26
OH	0.16	-0.03
OK	0.01	0.01
OR	0.03	0.17
PA	0.34	0.15
RI	0.39	0.37
SC	0.63	0.14
SD	0.14	0.47
TN	0.60	0.47
TX	0.30	-0.15
UT	-0.14	0.00
VT	0.14	0.19
VA	0.42	0.02
WA	-0.03	0.17
WV	0.51	0.20
WI	-0.04	0.17
WY	0.16	0.34
CENRAP	0.18	0.25
MANE-VU	0.26	0.20
MW RPO	0.03	0.03
VISTAS	0.57	0.28
WRAP	0.14	0.21
DOMAIN	0.24	0.72

Figure 3-27: Mixing Ratio Bias (g/kg) for ETA and NNRP MM5 Simulations of 2001 February 2-26. Regions were the ETA model is better are shaded blue.

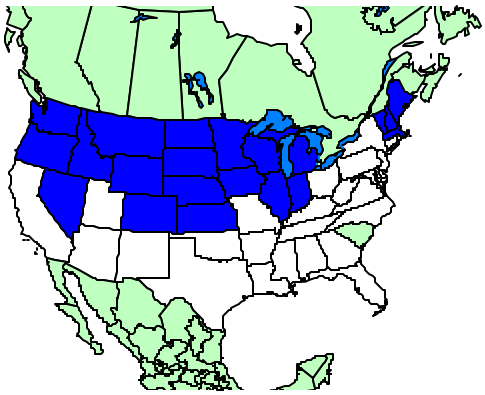


Table 3-5: Mixing Ratio Error (g/kg) for ETA and NNRP MM5 Simulations of 2001 February 2-26. Regions where the ETA model is better are shaded blue.

State	ETA Error (g/kg)	NNRP Error (g/kg)
AL	1.00	1.00
AK	0.40	
AZ	0.91	0.85
AR	0.82	0.91
CA	0.77	0.78
CO	0.53	0.66
CT	0.49	0.51
DE	0.48	0.43
DC	0.51	0.59
FL	1.28	1.26
GA	1.03	0.95
ID	0.51	0.68
IL	0.40	0.60
IN	0.47	0.61
IA	0.33	0.66
KS	0.46	0.82
KY	0.68	0.79
LA	1.07	1.17
ME	.033	0.45
MD	0.61	0.58
MA	0.45	.054
MI	0.32	0.44
MN	0.25	0.41
MS	1.02	1.02
MO	0.53	0.75
MT	0.38	0.53
NE	0.35	0.65
NV	0.57	0.71
NH	0.37	0.49
NJ	0.55	0.54
NM	0.89	0.83
NY	0.40	0.43
NC	0.99	0.85
ND	0.21	0.34
OH	0.47	0.52
OK	0.65	1.01
OR	0.49	0.66
PA	0.56	0.53
RI	0.51	0.54
SC	1.03	0.91
SD	0.29	0.55
TN	0.81	0.83
TX	0.96	1.14
UT	0.58	0.67
VT	0.32	0.41
VA	0.77	0.72
WA	0.43	0.63
WV	0.71	0.71
WI	0.28	0.47
WY	0.43	0.59
CENRAP	0.58	0.80
MANE-VU	0.45	0.49
MW RPO	0.36	0.50
VISTAS	0.99	0.94
WRAP	0.59	0.69
DOMAIN	0.62	0.72

Figure 3-28: Mixing Ratio Error (g/kg) for ETA and NNRP MM5 Simulations of 2001 February 2-26. Regions where the ETA model is better are shaded blue.

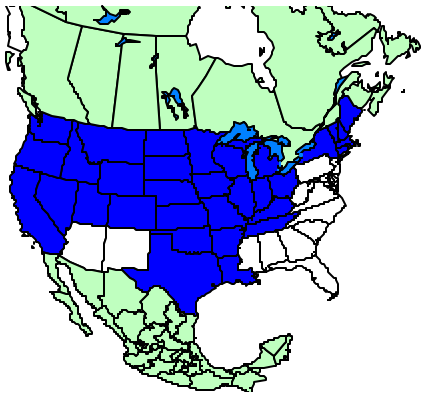


Table 3-6: Temperature Bias for ETA and NNRP MM5 Simulations of 2001 July 2-26. Regions where the ETA model is better are shaded blue.

State	ETA Bias (K)	NNRP Bias (K)
AL	0.74	0.78
AK	-1.40	
AZ	-2.94	-3.89
AR	0.55	0.92
CA	-2.86	-3.96
CO	-2.22	-3.38
CT	0.07	-0.84
DE	-0.88	-1.05
DC	-0.62	-1.00
FL	-0.06	-0.68
GA	0.56	0.43
ID	-1.62	-2.52
IL	0.76	-0.14
IN	1.11	0.28
IA	0.69	-0.28
KS	-0.86	-1.32
KY	0.71	0.54
LA	-0.02	0.16
ME	0.19	-0.42
MD	0.18	-0.32
MA	-0.07	-0.60
MI	0.08	-0.97
MN	1.21	-0.15
MS	0.72	0.91
MO	0.90	0.61
MT	-1.48	-2.29
NE	0.44	-1.14
NV	-3.90	-4.95
NH	0.78	-0.08
NJ	-0.07	-0.93
NM	-2.39	-3.14
NY	-0.16	-1.08
NC	0.36	0.18
ND	0.86	0.05
OH	0.59	-0.46
OK	-0.96	-0.77
OR	-2.60	-4.16
PA	0.21	-0.43
RI	0.06	-0.68
SC	0.33	0.31
SD	0.48	-0.74
TN	0.35	0.44
TX	-1.24	-1.77
UT	-3.41	-3.68
VT	-0.02	-0.62
VA	-0.06	-0.12
WA	-1.11	-2.17
WV	0.75	0.69
WI	0.86	-0.33
WY	-2.38	-3.19
CENRAP	0.08	-0.60
MANE-VU	0.05	-0.66
MW RPO	0.57	-0.47
VISTAS	0.31	0.13
WRAP	-2.15	-3.19
DOMAIN	-0.41	-1.13

Figure 3-29: Temperature Bias for ETA and NNRP MM5 Simulations of 2001 July 2-26. Regions where the ETA model is better are shaded blue.

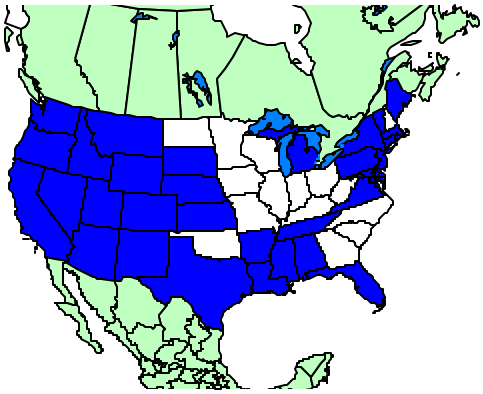


Table 3-7: Temperature Error for ETA and NNRP MM5 Simulations of 2001 July 2-26. Regions where the ETA model is better are shaded blue.

State	ETA Error (K)	NNRP Error (K)
AL	1.71	2.01
AK	1.62	
AZ	3.99	4.64
AR	1.64	2.04
CA	3.44	4.41
CO	3.33	4.23
CT	1.70	2.32
DE	2.13	2.50
DC	1.37	2.23
FL	1.72	2.04
GA	1.62	1.98
ID	3.38	3.99
IL	1.91	2.62
IN	1.82	2.25
IA	1.79	2.33
KS	2.18	2.69
KY	1.68	2.16
LA	1.80	1.95
ME	1.52	2.40
MD	1.81	2.54
MA	1.90	2.45
MI	2.08	2.76
MN	2.20	2.44
MS	1.65	2.02
MO	1.79	2.17
MT	2.96	3.65
NE	2.04	2.60
NV	4.63	5.60
NH	2.45	3.28
NJ	1.72	2.55
NM	3.09	3.69
NY	1.69	2.56
NC	1.57	2.22
ND	1.95	2.30
OH	1.68	2.38
OK	1.82	2.25
OR	3.34	4.66
PA	1.68	2.36
RI	1.53	2.13
SC	1.38	1.99
SD	2.13	2.58
TN	1.56	2.01
TX	1.90	2.45
UT	4.32	4.58
VT	1.71	2.48
VA	1.83	2.52
WA	2.49	3.13
WV	1.74	2.29
WI	2.06	2.74
WY	3.33	4.11
CENRAP	1.95	2.37
MANE-VU	1.76	2.51
MW RPO	1.96	2.62
VISTAS	1.66	2.15
WRAP	3.23	4.05
DOMAIN	2.22	2.82

Figure 3-30: Temperature Error for ETA and NNRP MM5 Simulations of 2001 July 2-26. Regions where the ETA model is better are shaded blue.

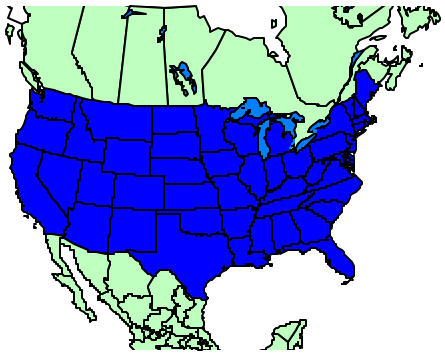


Table 3-8: Mixing Ratio Bias (g/kg) for ETA and NNRP MM5 Simulations of 2001 July 2-26. Regions where the ETA model is better are shaded blue.

State	ETA Bias (g/kg)	NNRP Bias (g/kg)
AL	-2.15	-1.37
AK	0.09	
AZ	0.35	-1.20
AR	-1.93	-1.52
CA	0.15	-0.06
CO	-1.18	-0.17
CT	-1.36	-0.71
DE	-0.91	-0.49
DC	-1.74	-1.37
FL	-0.89	0.25
GA	-1.96	-1.13
ID	-0.25	-0.69
IL	-1.22	-1.67
IN	-1.74	-1.95
IA	-1.97	-1.95
KS	-0.78	-0.99
KY	-1.30	-1.87
LA	-1.14	0.29
ME	-0.55	-0.23
MD	-1.02	-0.72
MA	-0.79	-0.24
MI	-0.74	-0.77
MN	-0.86	-1.05
MS	-2.33	-1.02
MO	-2.21	-2.23
MT	-.083	-1.12
NE	-1.27	-1.39
NV	0.33	0.05
NH	-1.16	-0.51
NJ	-1.27	-0.68
NM	-0.74	0.18
NY	-1.19	-0.61
NC	-1.14	-0.83
ND	-2.07	-2.17
OH	-1.28	-1.90
OK	-1.50	-1.61
OR	-0.02	-0.29
PA	-1.20	-0.96
RI	-0.49	-0.03
SC	-1.46	-1.00
SD	-1.38	-1.91
TN	-1.95	-2.02
TX	-0.33	-0.53
UT	0.38	-0.35
VT	-1.25	-0.59
VA	-1.61	-1.34
WA	-0.25	-0.53
WV	-1.84	-2.16
WI	-1.11	-1.20
WY	-0.50	-0.69
CENRAP	-1.13	-1.13
MANE-VU	-1.05	-0.58
MW RPO	-1.09	-1.32
VISTAS	-1.49	-0.93
WRAP	-0.32	-0.50
DOMAIN	-0.97	-1.37

Figure 3-31: : Mixing Ratio Bias (g/kg) for ETA and NNRP MM5 Simulations of 2001 July 2-26. Regions where the ETA model is better are shaded blue.

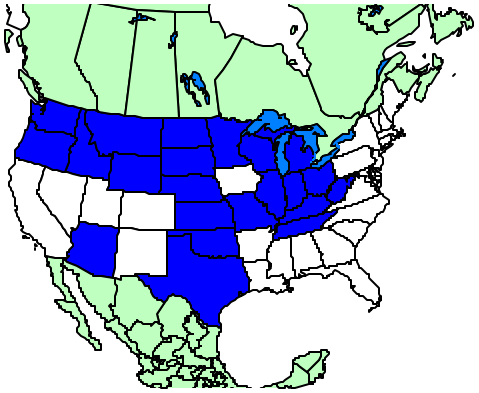


Table 3-9: Mixing Ratio Error (g/kg) for ETA and NNRP MM5 Simulations of 2001 July 2-26. Regions where the ETA model is better are shaded blue.

State	ETA Error (g/kg)	NNRP Error (g/kg)
AL	2.46	2.21
AK	0.59	
AZ	2.62	2.60
AR	2.35	2.20
CA	1.44	1.39
CO	2.11	1.93
CT	1.74	1.91
DE	1.38	1.47
DC	1.98	2.17
FL	1.69	1.52
GA	2.34	2.14
ID	1.59	1.74
IL	2.02	2.32
IN	2.20	2.31
IA	2.53	2.55
KS	2.30	2.24
KY	1.83	2.34
LA	2.75	2.63
ME	1.30	1.33
MD	1.62	1.82
MA	1.39	1.75
MI	1.55	1.83
MN	1.85	2.06
MS	2.63	2.19
MO	2.59	2.65
MT	1.64	1.98
NE	2.28	2.33
NV	2.10	1.87
NH	1.49	1.71
NJ	1.81	1.97
NM	2.10	2.02
NY	1.65	1.76
NC	1.84	1.99
ND	2.36	2.69
OH	1.76	2.25
OK	2.48	2.52
OR	1.22	1.21
PA	1.75	2.02
RI	1.23	1.64
SC	1.89	1.87
SD	2.10	2.67
TN	2.26	2.55
TX	2.02	1.98
UT	1.98	1.95
VT	1.60	1.59
VA	2.01	2.27
WA	1.14	1.09
WV	2.15	2.71
WI	1.85	2.09
WY	1.82	1.94
CENRAP	2.22	2.25
MANE-VU	1.58	1.77
MW RPO	1.79	2.09
VISTAS	2.02	2.05
WRAP	1.71	1.76
DOMAIN	1.91	2.21

Figure 3-32: Mixing Ratio Error (g/kg) for ETA and NNRP MM5 Simulations of 2001 July 2-26. Regions where the ETA model is better are shaded blue.

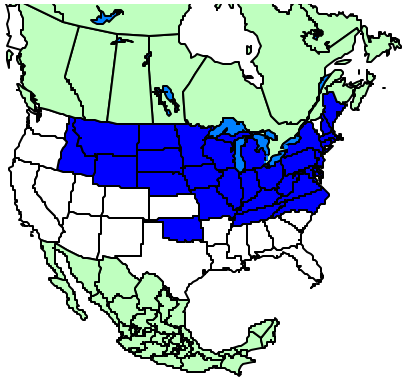


Table 3-10: Wind Index of Agreement (IA) for ETA and NNRP MM5 Simulations of 2001 February 2-26. Regions where the ETA model is better are shaded blue.

State	ETA IA	NNRP IA
AL	0.68	0.64
AK	0.53	
AZ	0.73	0.66
AR	0.70	0.65
CA	0.78	0.71
CO	0.76	0.71
CT	0.52	0.47
DE	0.74	0.70
DC		
FL	0.73	0.68
GA	0.60	0.54
ID	0.70	0.65
IL	0.64	0.57
IN	0.62	0.54
IA	0.64	0.58
KS	0.68	0.64
KY	0.56	0.52
LA	0.66	0.60
ME	0.55	0.48
MD	0.51	0.49
MA	0.54	0.49
MI	0.68	0.59
MN	0.68	0.62
MS	0.58	0.53
MO	0.63	0.58
MT	0.76	0.71
NE	0.71	0.65
NV	0.73	0.67
NH	0.30	0.35
NJ	0.52	0.45
NM	0.75	0.69
NY	0.70	0.65
NC	0.62	0.56
ND	0.72	0.66
OH	0.61	0.56
OK	0.57	0.56
OR	0.75	0.69
PA	0.67	0.65
RI	0.54	0.52
SC	0.57	0.52
SD	0.75	0.70
TN	0.65	0.58
TX	0.77	0.68
UT	0.75	0.71
VT	0.46	0.44
VA	0.66	0.61
WA	0.72	0.67
WV	0.57	0.51
WI	0.64	0.51
WY	0.74	0.66
CENRAP	0.87	0.82
MANE-VU	0.68	0.63
MW RPO	0.76	0.67
VISTAS	0.80	0.74
WRAP	0.87	0.81
DOMAIN	0.90	0.85

Figure 3-33: Wind Index of Agreement (IA) for ETA and NNRP MM5 Simulations of 2001 February 2-26. Regions where the ETA model is better are shaded blue.

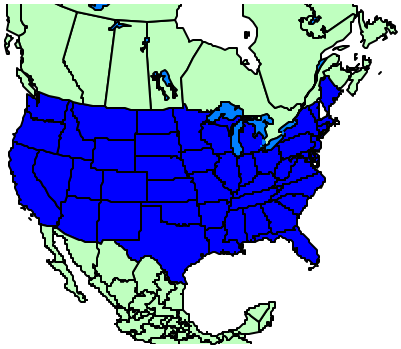
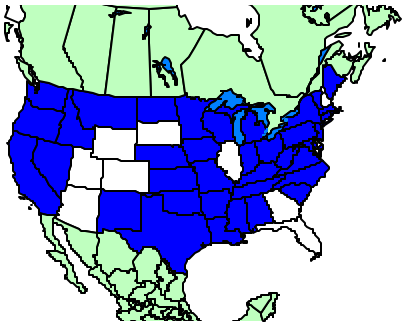


Table 3-11: Wind Index of Agreement (IA) for ETA and NNRP MM5 Simulations of 2001 July 2-26. Regions where the ETA model is better are shaded blue.

State	ETA IA	NNRP IA
AL	0.71	0.59
AK	0.57	
AZ	0.62	0.67
AR	0.66	0.56
CA	0.80	0.75
CO	0.73	0.77
CT	0.52	0.47
DE	0.69	0.57
DC		
FL	0.73	0.64
GA	0.67	0.53
ID	0.69	0.70
IL	0.64	0.57
IN	0.58	0.51
IA	0.64	0.54
KS	0.64	0.55
KY	0.53	0.47
LA	0.64	0.58
ME	0.59	0.47
MD	0.60	0.49
MA	0.58	0.51
MI	0.66	0.54
MN	0.65	0.54
MS	0.63	0.50
MO	0.69	0.58
MT	0.74	0.73
NE	0.66	0.61
NV	0.70	0.68
NH	0.43	0.46
NJ	0.53	0.47
NM	0.72	0.68
NY	0.68	0.59
NC	0.64	0.54
ND	0.69	0.60
OH	0.61	0.51
OK	0.93	0.51
OR	0.76	0.72
PA	0.64	0.55
RI	0.51	0.48
SC	0.61	0.53
SD	0.67	0.67
TN	0.58	0.50
TX	0.76	0.63
UT	0.71	0.71
VT	0.51	0.42
VA	0.66	0.55
WA	0.77	0.75
WV	0.54	0.45
WI	0.61	0.52
WY	0.73	0.73
CENRAP	0.83	0.72
MANE-VU	0.69	0.59
MW RPO	0.71	0.62
VISTAS	0.79	0.68
WRAP	0.85	0.83
DOMAIN	0.87	0.80

Figure 3-34: Wind Index of Agreement (IA) for ETA and NNRP MM5 Simulations of 2001 July 2-26. Regions where the ETA model is better are shaded blue.



4 DISCUSSION

From a statistical basis looking at temperature, mixing ratio and wind index of agreement, for national scale modeling it appears that it is advantageous to use the ETA first-guess fields over the NNRP first guess fields. The ETA configuration model had consistently lower gross errors. The temperature and mixing ratio bias show regional trends, but without a clear pattern. Certain metrics make one configuration or the other look better in certain regions depending on the episode and metric. The lower bias can also be a statistical anomaly where model underestimates in certain times and regions are offsetting model overestimates at other times and regions.

From examination of the radar reflectivity data, it appears that the NNRP configuration delivers consistently better results. The NNRP configuration is better able to predict the location of precipitation events, and produces precipitation over larger areas than the ETA configuration.