

Evaluation of a 2010-2011 WRF Simulation Over the Midwest

Ad-Hoc Meteorological Modelers Meeting
Boulder, CO
06/28/2012

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Windsor Heights, IA 50324

Overview

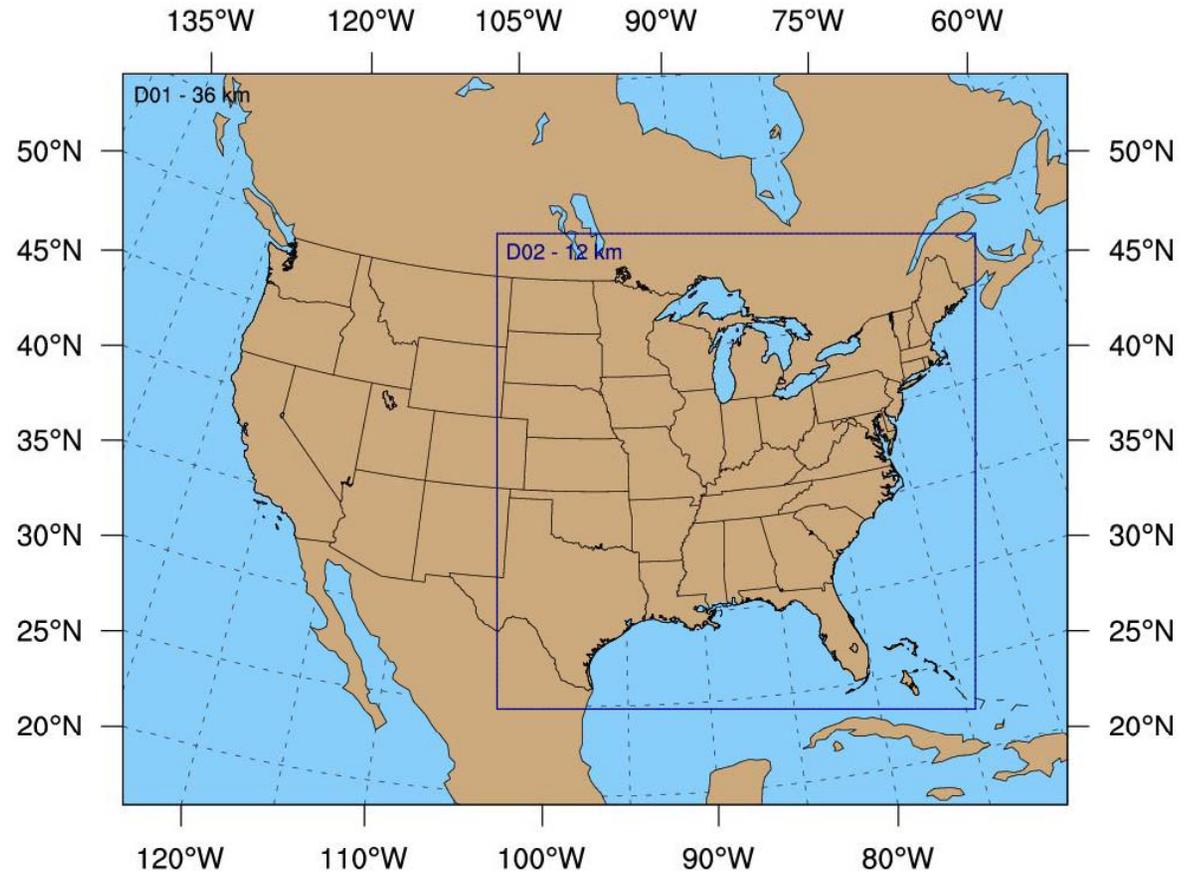
- **WI DNR generated a WRF dataset for LADCO AQ modeling**
 - January 2010-June 2011
 - CAMx modeling to support WI Biomass Fuels Study
 - Potential LADCO CAMx Modeling

- **WI Biomass Fuels Study**
 - Characterize the air quality impacts of biomass fuels at power plants in WI
 - July 2010-June 2011

Model Configuration

Map Projection	
Projection	Lambert
True Lat 1	33
True Lat 2	45
Stand Long	-97
Ref Long	-97
Ref Lat	40

Domains	1	2
NX (W-E)	165	250
NY (S-N)	129	250
Res (km)	36	12
Start Loc (i,j)	1,1	66,18
SW (x,y) (km)	-2952,-2304	-612,-1692
NE (x,y) (km)	-2952,-2304	2376,1296



Model Configuration (Cont.)

- 35 levels
- 50 mb model top
- ~20 m first layer
- Increased resolution near surface and model top

Level	Sigma	Height (m)	Pressure (mb)	Depth (m)
35	0.0000	18663	50	2034
34	0.0332	16629	82	1715
33	0.0682	14914	115	1515
32	0.1056	13399	150	1375
31	0.1465	12024	189	1255
30	0.1907	10769	231	1145
29	0.2378	9624	276	1045
28	0.2871	8579	323	955
27	0.3379	7624	371	870
26	0.3895	6754	420	790
25	0.4409	5964	469	715
24	0.4915	5249	517	645
23	0.5406	4604	564	580
22	0.5876	4024	608	520
21	0.6323	3504	651	465
20	0.6742	3039	690	415
19	0.7133	2624	728	370
18	0.7494	2254	762	330
17	0.7828	1924	794	293
16	0.8133	1631	823	259
15	0.8410	1372	849	228
14	0.8659	1144	873	200
13	0.8882	944	894	174
12	0.9079	770	913	150
11	0.9252	620	929	128
10	0.9401	492	943	108
9	0.9528	384	955	90
8	0.9635	294	965	74
7	0.9723	220	974	60
6	0.9796	160	981	48
5	0.9854	112	986	38
4	0.9900	74	991	30
3	0.9940	44	994	24
2	0.9974	20	998	20
1	1.0000	0	1000	0

Model Configuration (Cont.)

- **SESARM/IA 2007 WRF Configuration**

Planetary Boundary Layer	ACM2
Surface Layer	Pleim-Xiu
Land Surface Model	Pleim-Xiu
Microphysics	Morrison et al.
Radiation (Shortwave)	RRTMG
Radiation (Longwave)	RRTMG
Cumulus	Kain-Fritsch

Model Configuration (Cont.)

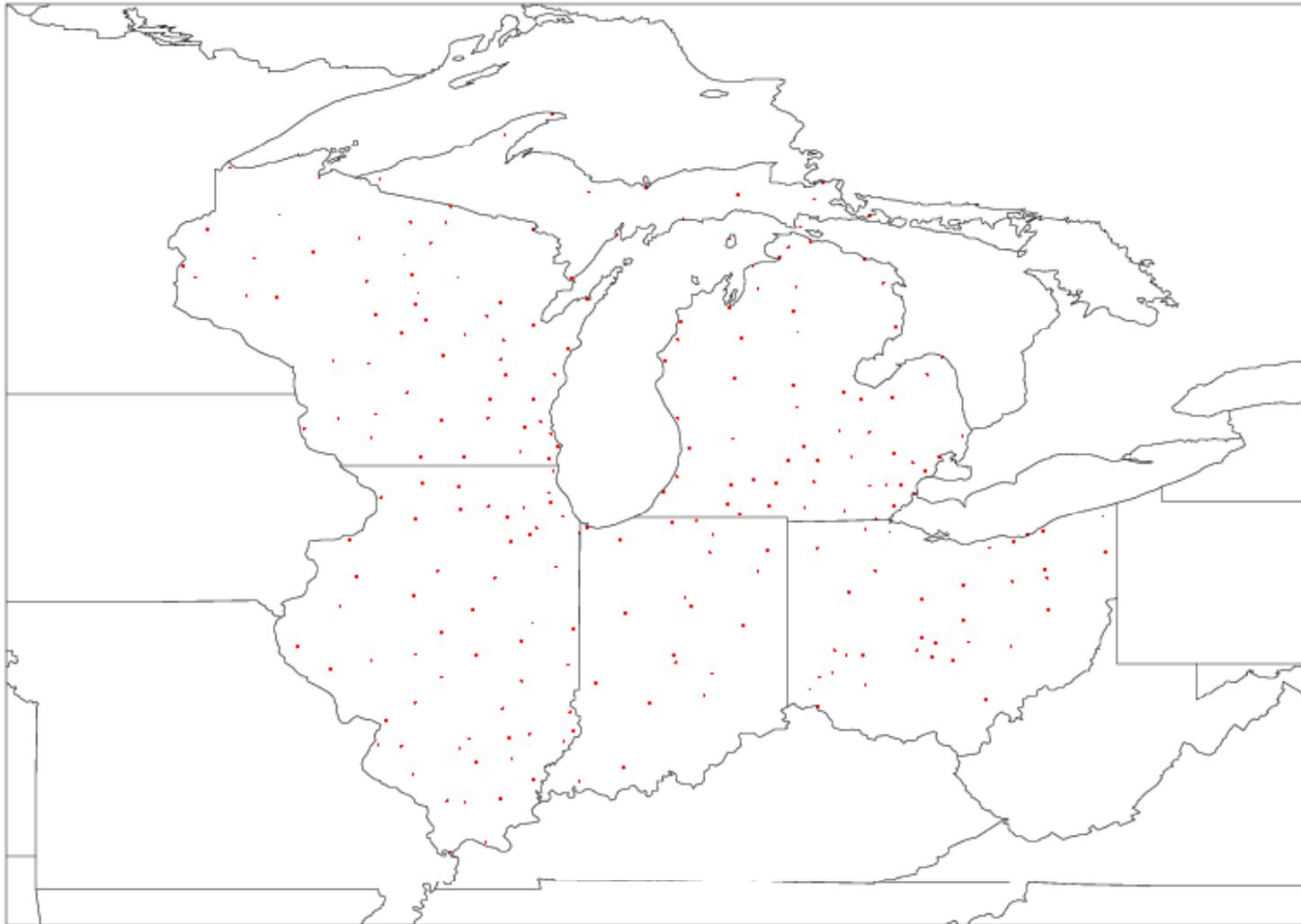
- **Initial and Boundary Conditions**
 - EDAS 3D and surface analysis
 - 40 km, 3-hrly

- **FDDA**
 - MADIS observations
 - OBSGRID gridded analysis nudging fields

Performance Evaluation

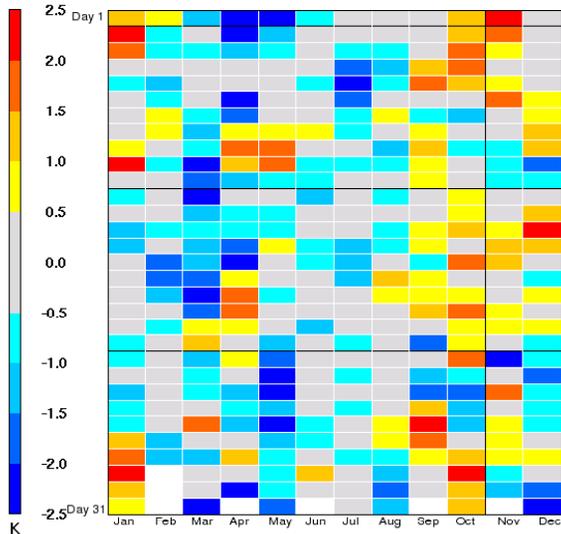
- **12 km domain**
- **Statistical evaluation of near-surface fields**
 - 2-m Temp, 2-m Mixing Ratio, 10-m Wind Speed
 - Bias, Gross Error, RMSE
- **Subjective evaluation**
 - **Precipitation**
 - Monthly accumulated precipitation vs NCEP Stage IV analysis
 - **Cloud Cover**
 - Cloud fields vs GOES-East brightness temperature

Performance Evaluation (Cont.)



Temperature Bias - MRPO Region

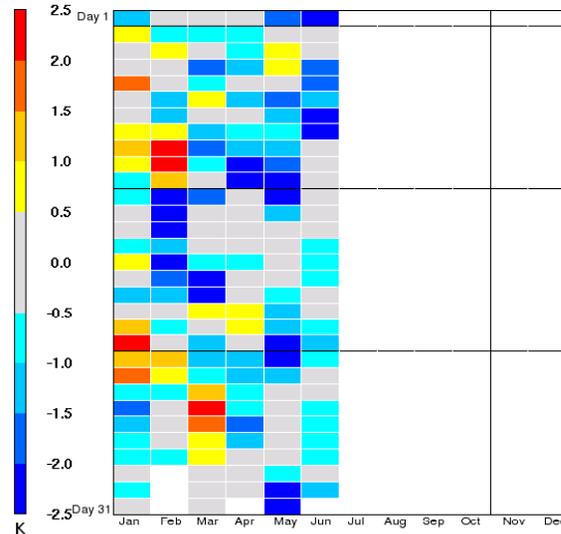
Annual 2010 WRFv311 Daily Metrics: 12 km
WI DNR



January 1, 2002 0:00:00
Min= -4.5 at (4,30), Max= 2.5 at (1,30)

Temperature Bias - MRPO Region

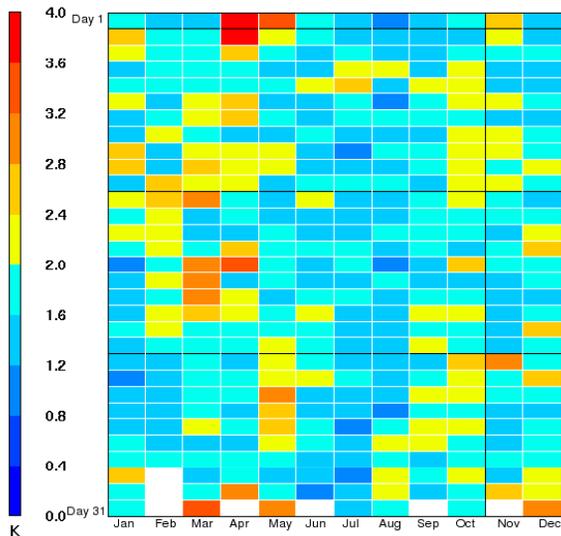
2011 WRFv311 Daily Metrics: 12 km
WI DNR



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Min= -3.9 at (5,1), Max= 2.4 at (2,23)

Temperature Gross Error - MRPO Region

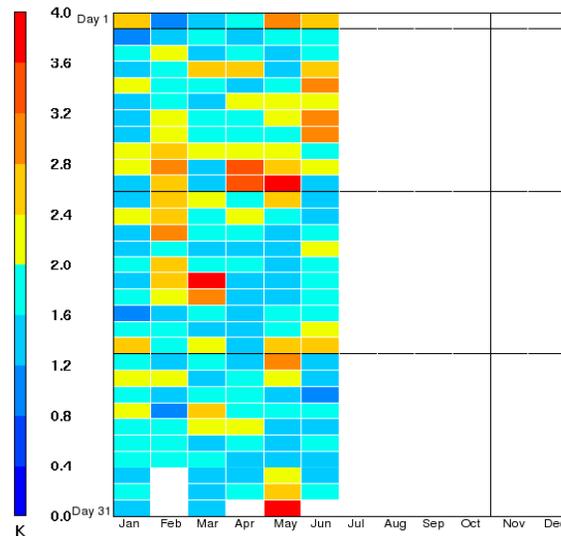
Annual 2010 WRFv311 Daily Metrics: 12 km
WI DNR



January 1, 2002 0:00:00
Min= 1.0 at (1,9), Max= 4.7 at (4,30)

Temperature Gross Error - MRPO Region

2011 WRFv311 Daily Metrics: 12 km
WI DNR

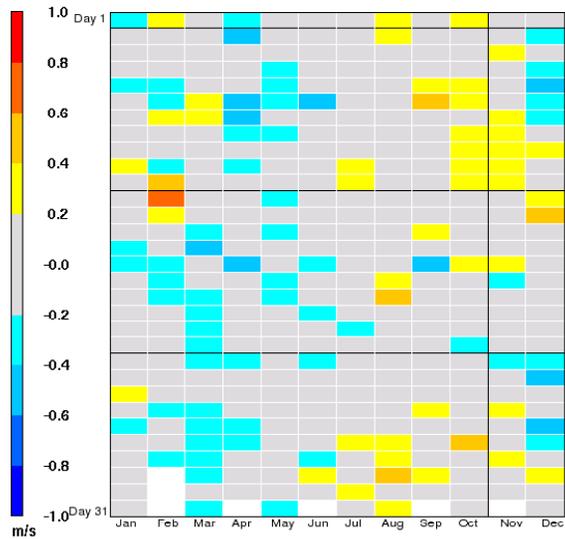


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Min= 1.1 at (2,31), Max= 4.2 at (5,1)



Wind Spd Bias - MRPO Region

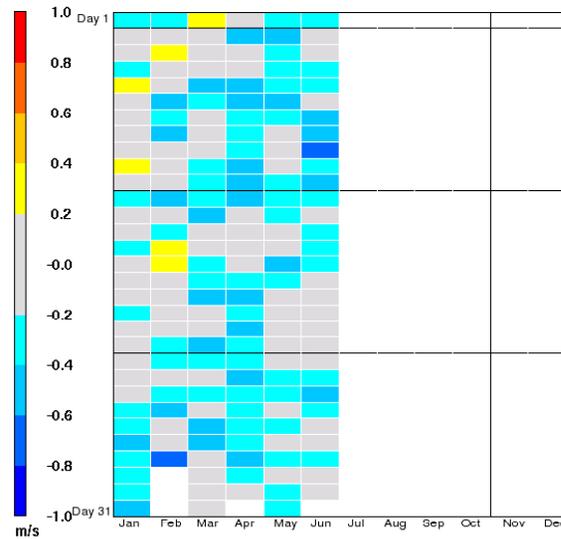
Annual 2010 WRFv311 Daily Metrics: 12 km
WI DNR



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Min= -0.5 at (12,27), Max= 0.7 at (2,20)

Wind Spd Bias - MRPO Region

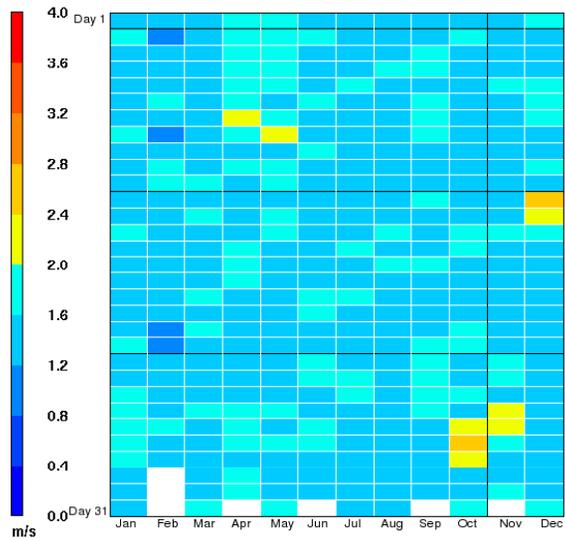
2011 WRFv311 Daily Metrics: 12 km
WI DNR



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Min= -0.6 at (2,4), Max= 0.3 at (2,16)

Wind Spd RMSE - MRPO Region

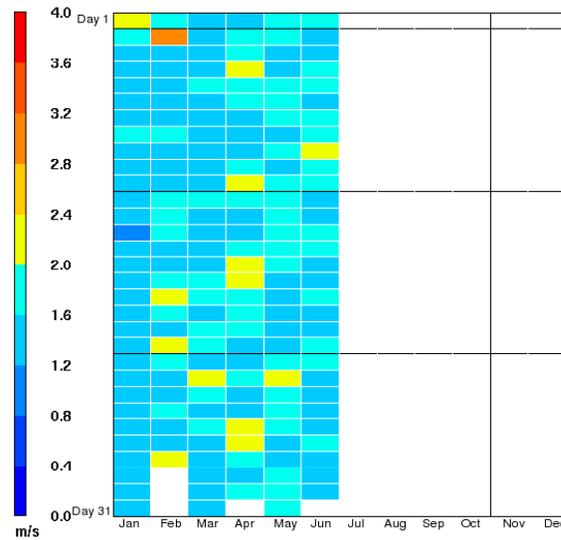
Annual 2010 WRFv311 Daily Metrics: 12 km
WI DNR



January 1, 2002 0:00:00
Min= 1.1 at (2,30), Max= 2.4 at (10,5)

Wind Spd RMSE - MRPO Region

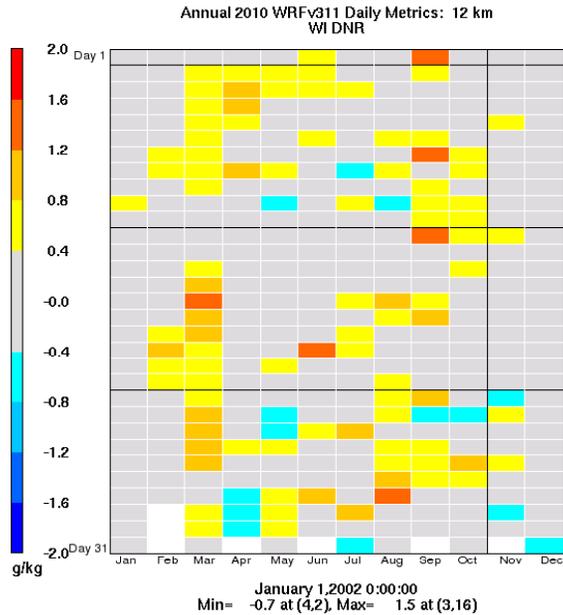
2011 WRFv311 Daily Metrics: 12 km
WI DNR



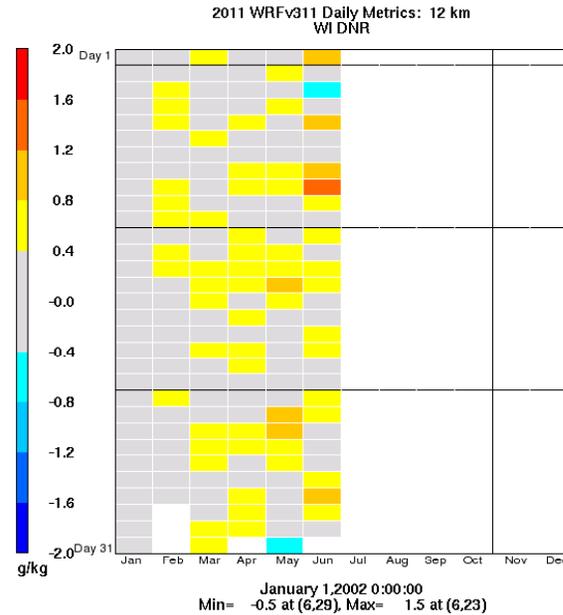
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Min= 1.1 at (1,18), Max= 2.8 at (2,30)



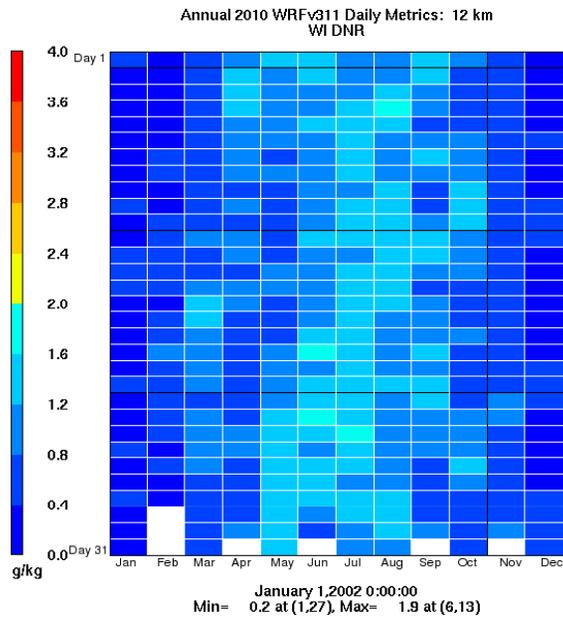
Mixing Ratio Bias - MRPO Region



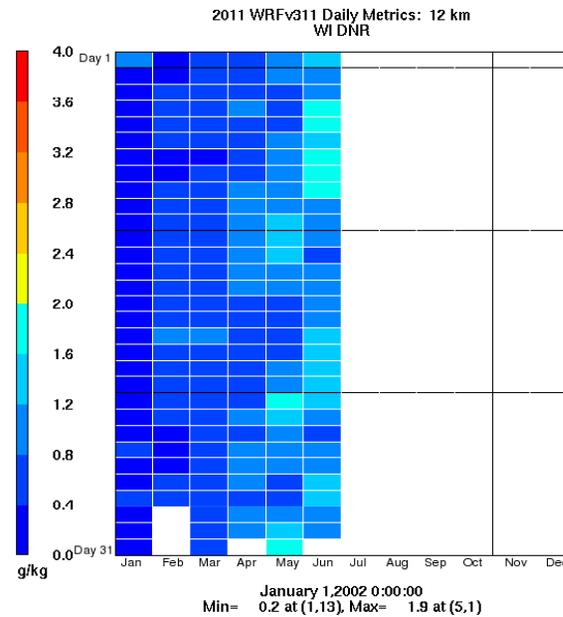
Mixing Ratio Bias - MRPO Region



Mixing Ratio Gross Error - MRPO Region

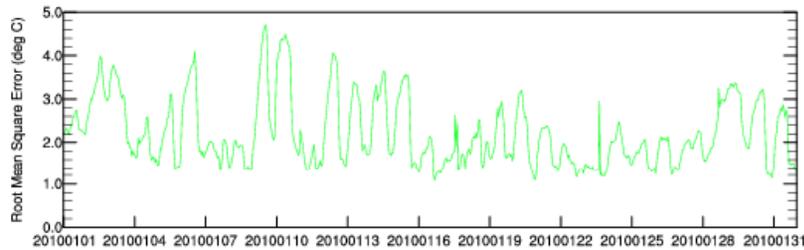
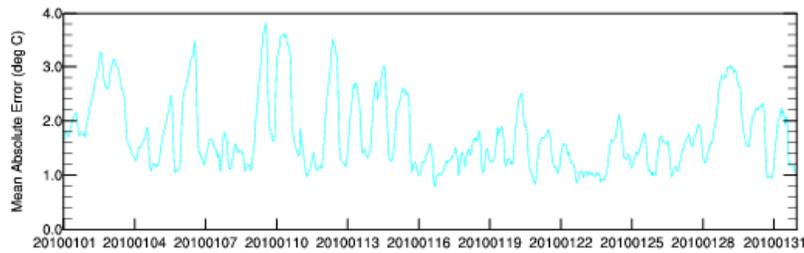
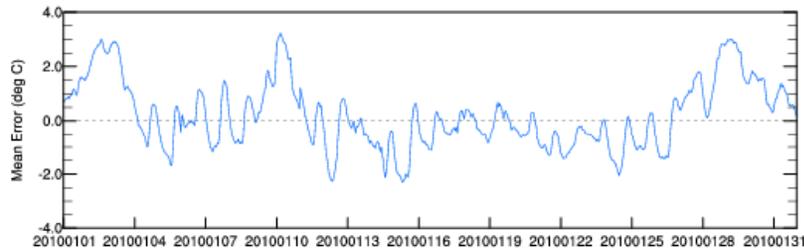
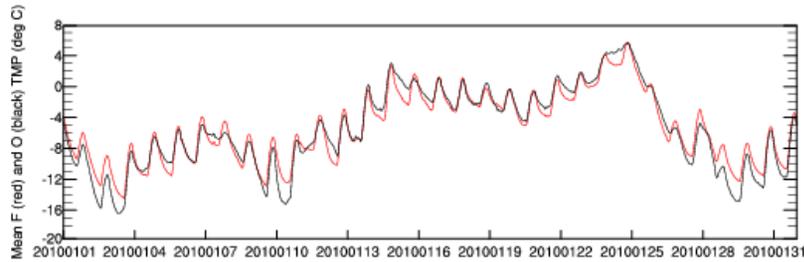


Mixing Ratio Gross Error - MRPO Region

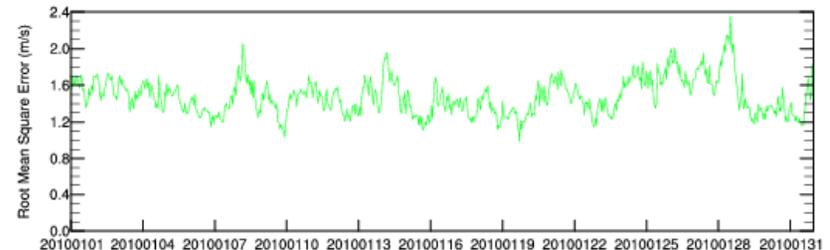
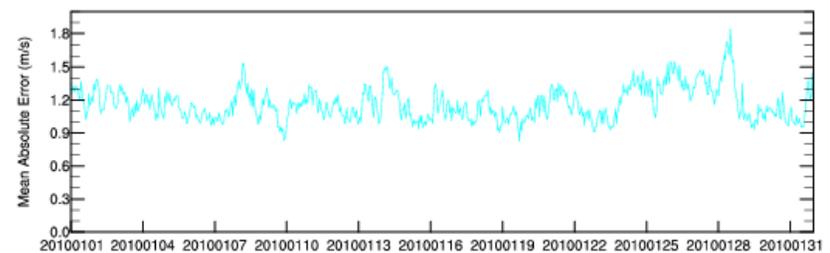
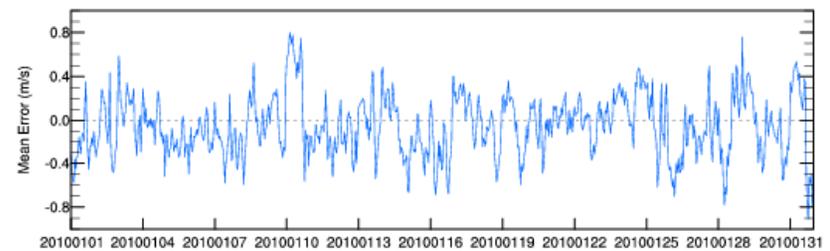
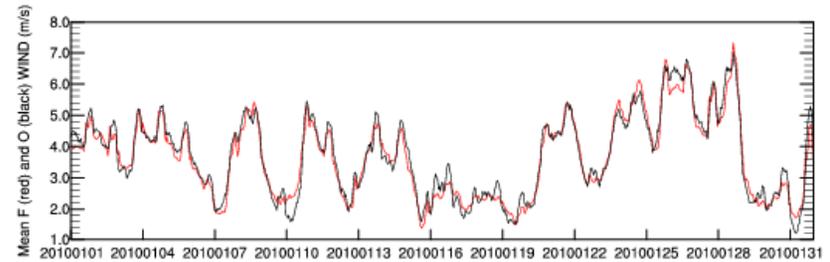


January 2010

Hourly Statistics - Temperature - MRPO - D02 - 201001

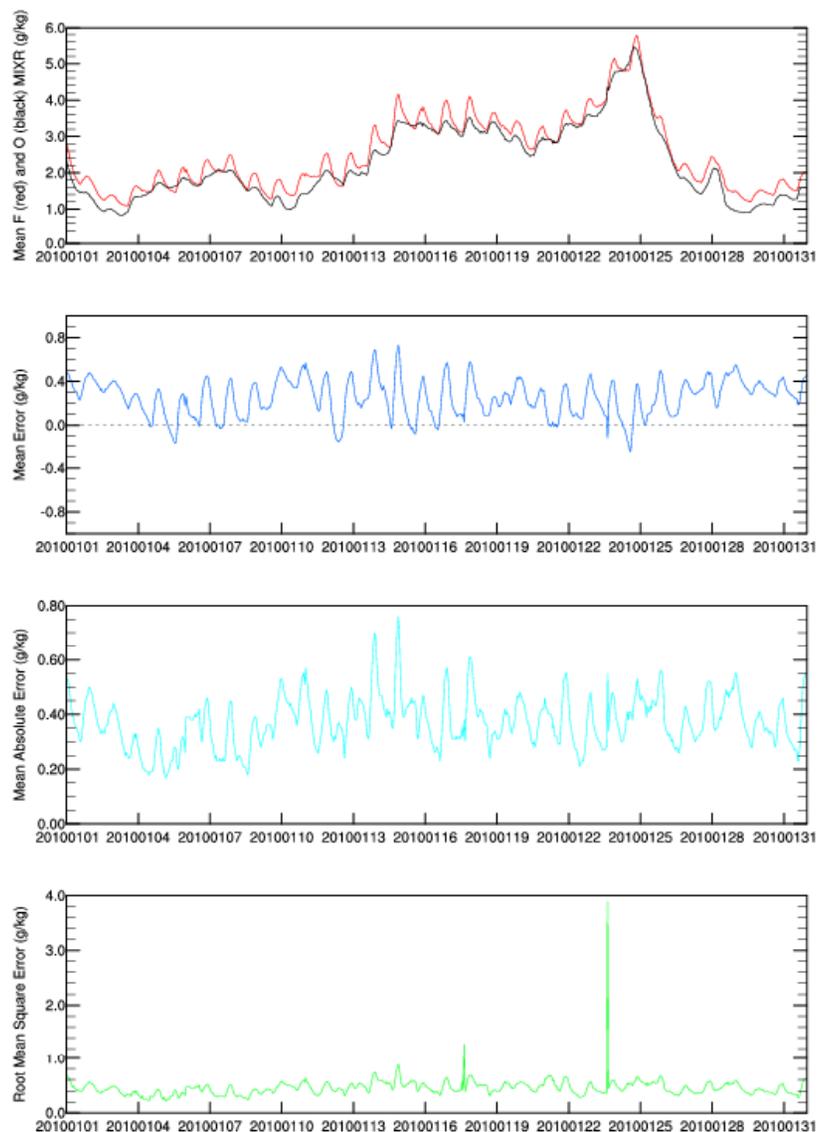


Hourly Statistics - Wind Speed - MRPO - D02 - 201001



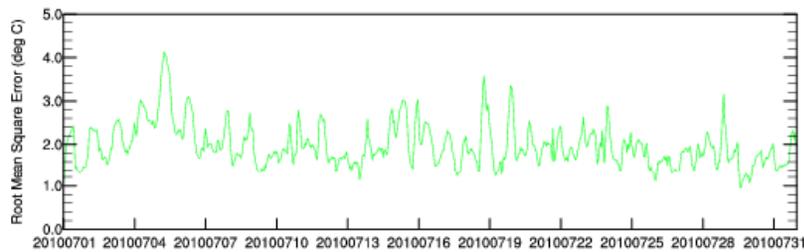
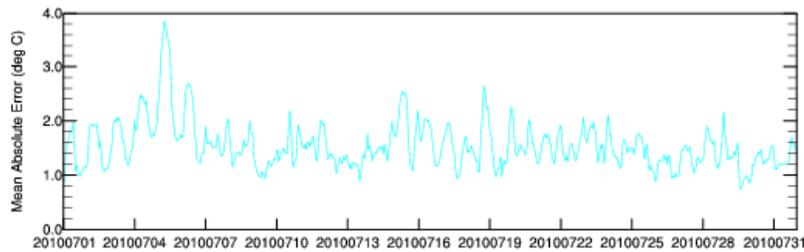
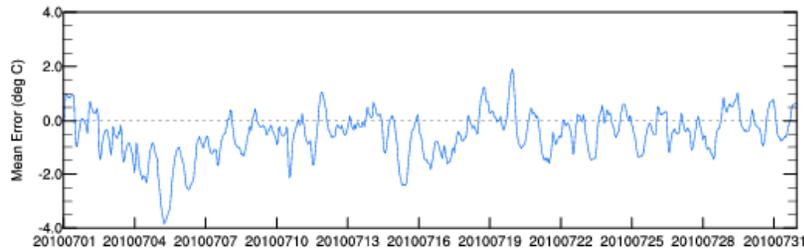
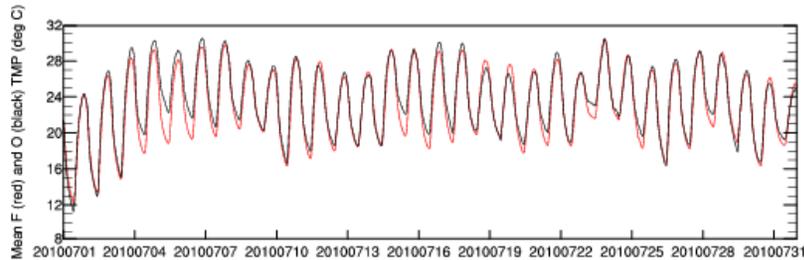
January 2010

Hourly Statistics - Mixing Ratio - MRPO - D02 - 201001

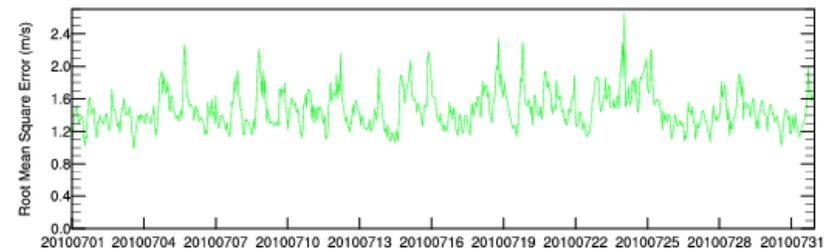
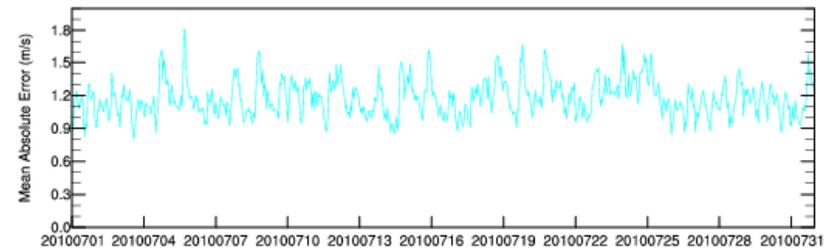
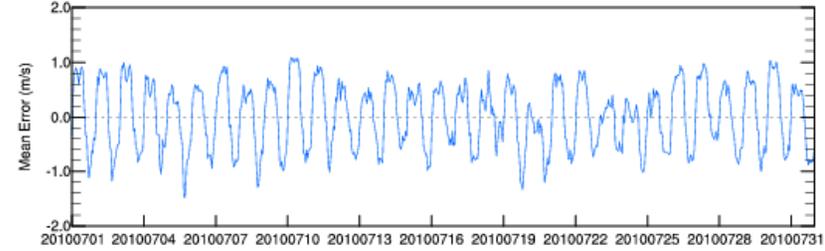
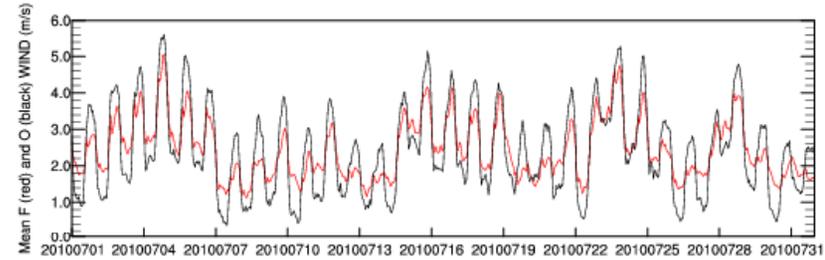


July 2010

Hourly Statistics - Temperature - MRPO - D02 - 201007

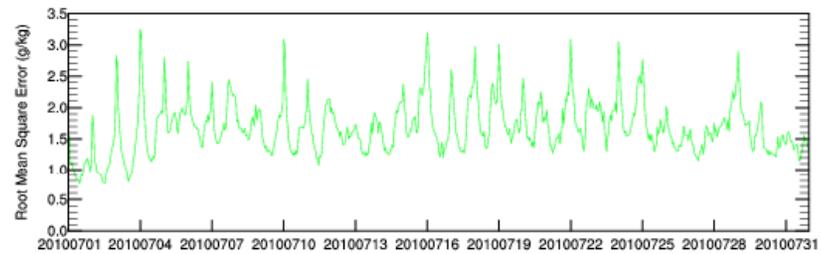
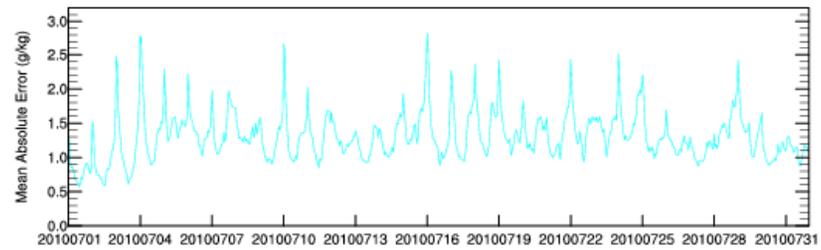
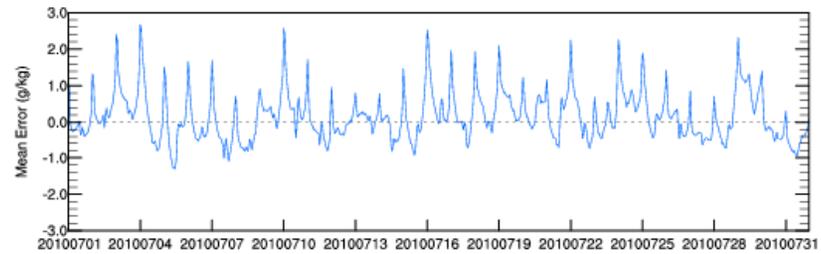
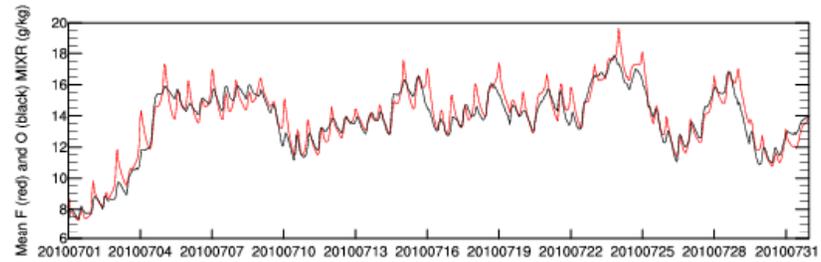


Hourly Statistics - Wind Speed - MRPO - D02 - 201007



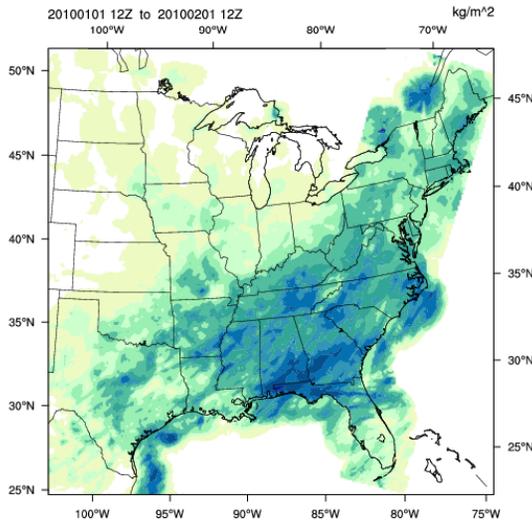
July 2010

Hourly Statistics - Mixing Ratio - MRPO - D02 - 201007

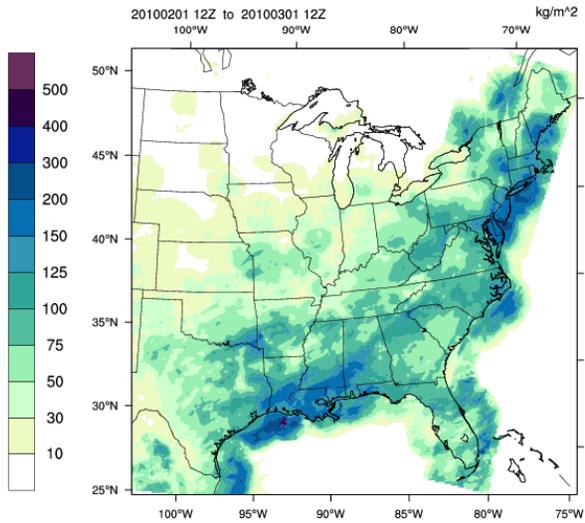


January – March, 2010

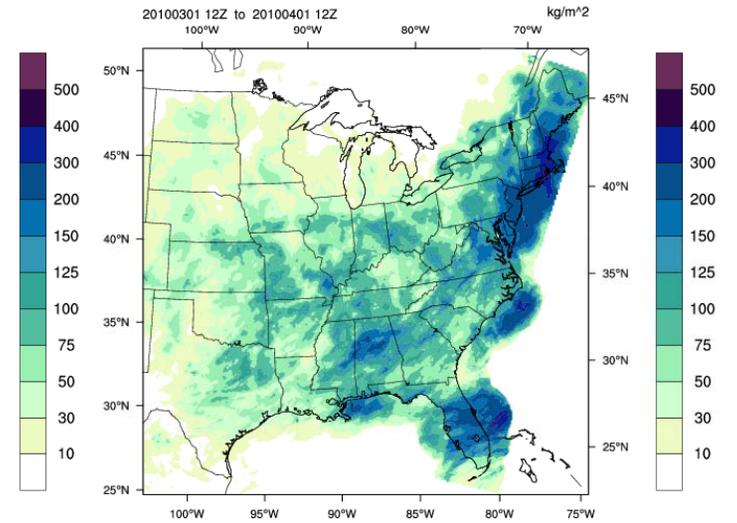
NCEP Stage IV Precipitation Analysis (Accumulated)



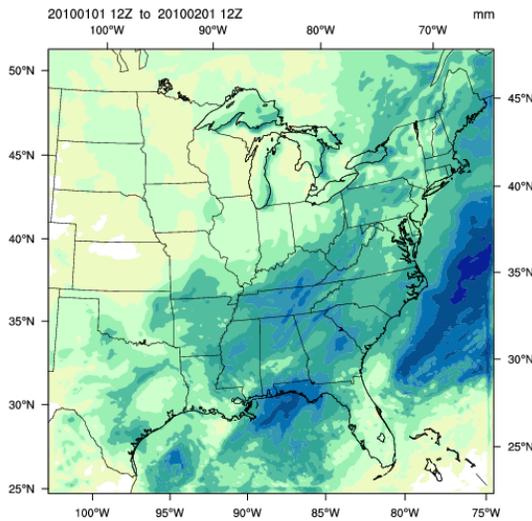
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NCEP Stage IV Precipitation Analysis (Accumulated)

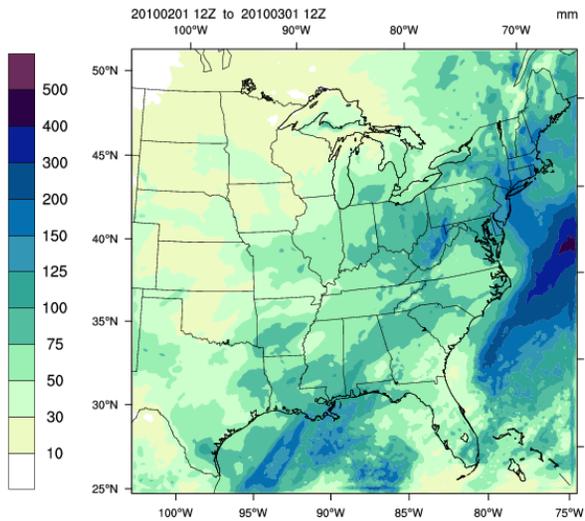


WRF-ARW Accumulated Precipitation



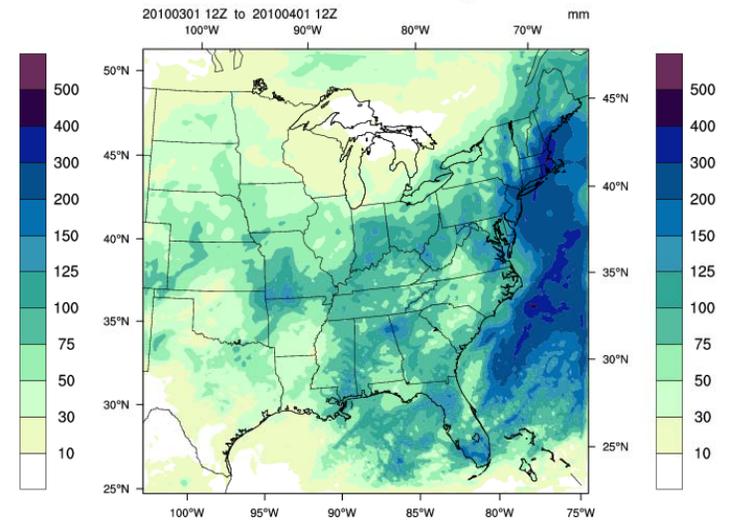
OUTPUT FROM WRF V3.1.1 MODEL
NK: 250 ; NY: 250 ; NZ: 35 ; Res: 12 km ; LSM: 7 ; PBL: 7 ; MP: 10 ; SW: 4 ; LW: 4 ; Cu: 1

WRF-ARW Accumulated Precipitation



OUTPUT FROM WRF V3.1.1 MODEL
NK: 250 ; NY: 250 ; NZ: 35 ; Res: 12 km ; LSM: 7 ; PBL: 7 ; MP: 10 ; SW: 4 ; LW: 4 ; Cu: 1

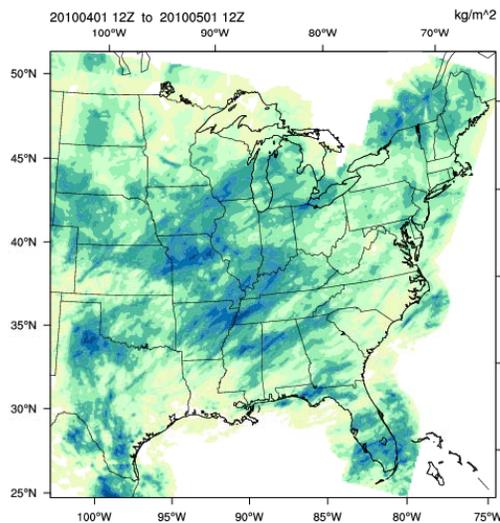
WRF-ARW Accumulated Precipitation



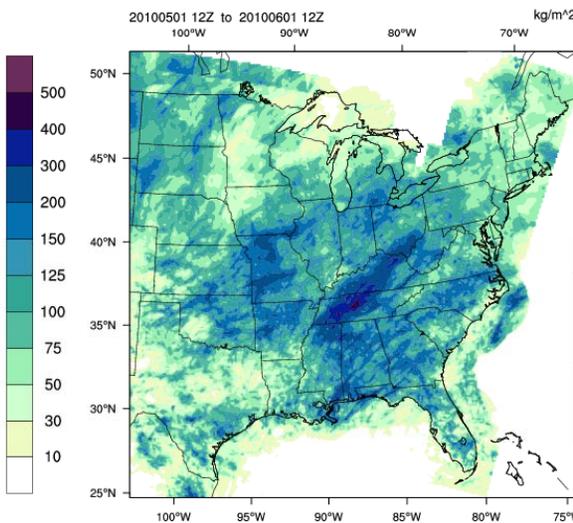
OUTPUT FROM WRF V3.1.1 MODEL
NK: 250 ; NY: 250 ; NZ: 35 ; Res: 12 km ; LSM: 7 ; PBL: 7 ; MP: 10 ; SW: 4 ; LW: 4 ; Cu: 1

April – June, 2010

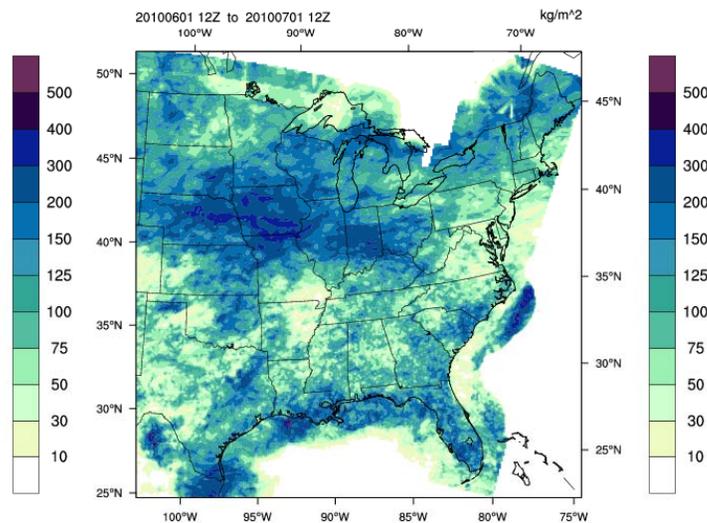
NCEP Stage IV Precipitation Analysis (Accumulated)



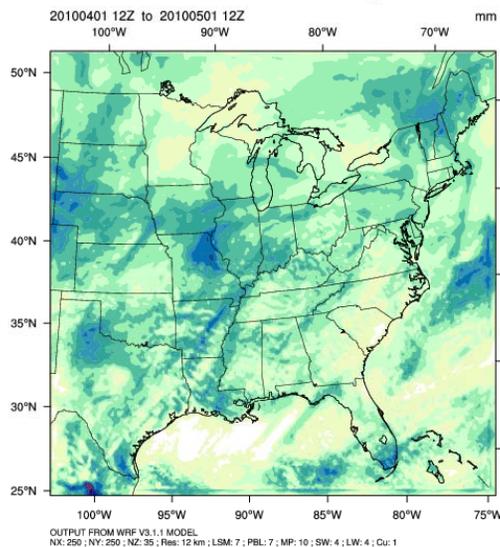
NCEP Stage IV Precipitation Analysis (Accumulated)



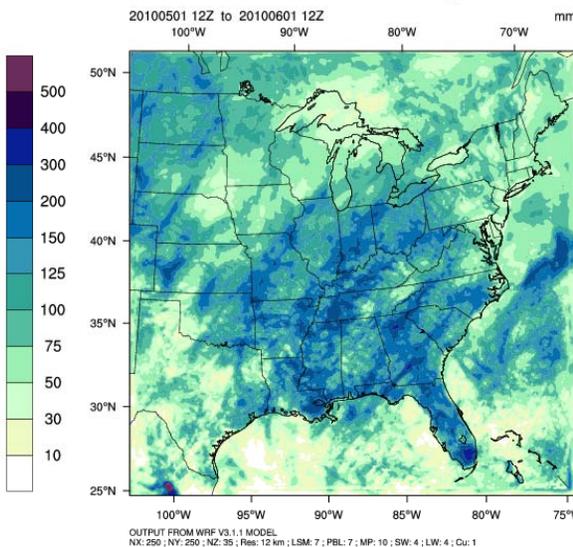
NCEP Stage IV Precipitation Analysis (Accumulated)



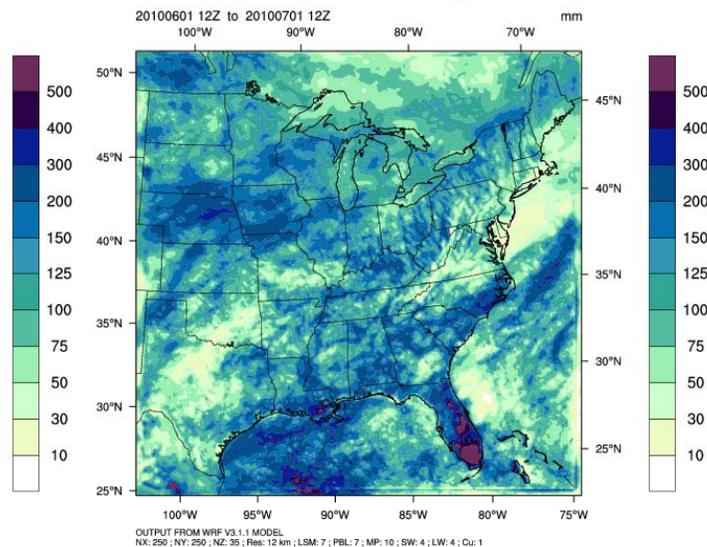
WRF-ARW Accumulated Precipitation



WRF-ARW Accumulated Precipitation

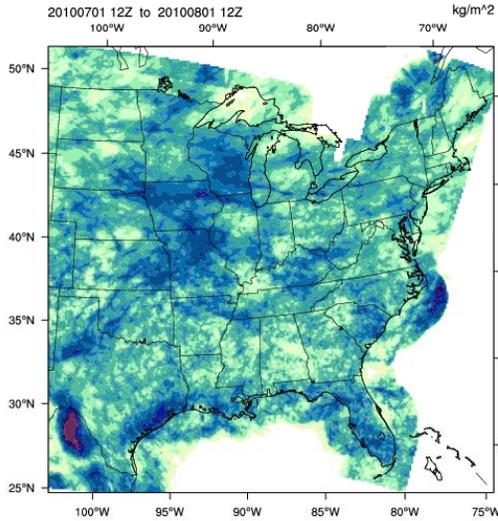


WRF-ARW Accumulated Precipitation

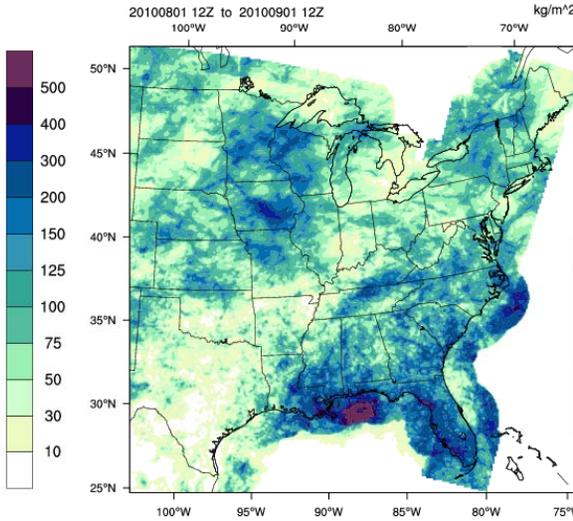


July – September, 2010

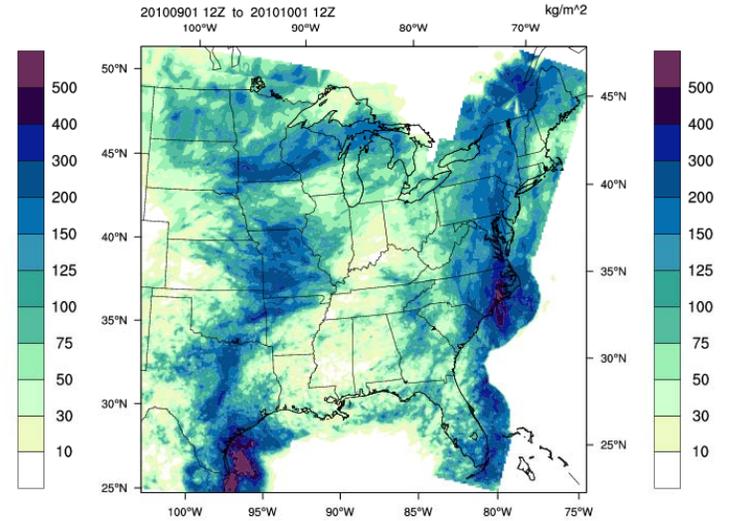
NCEP Stage IV Precipitation Analysis (Accumulated)



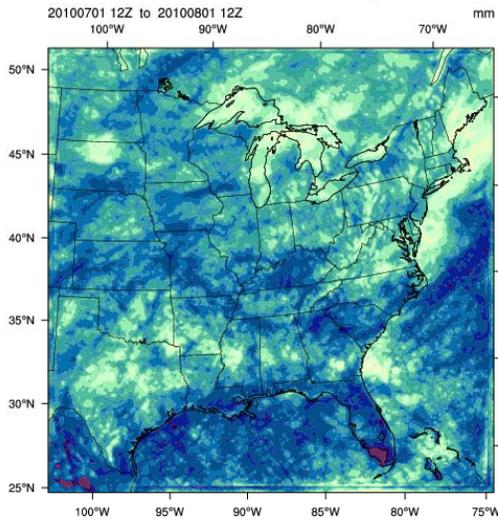
NCEP Stage IV Precipitation Analysis (Accumulated)



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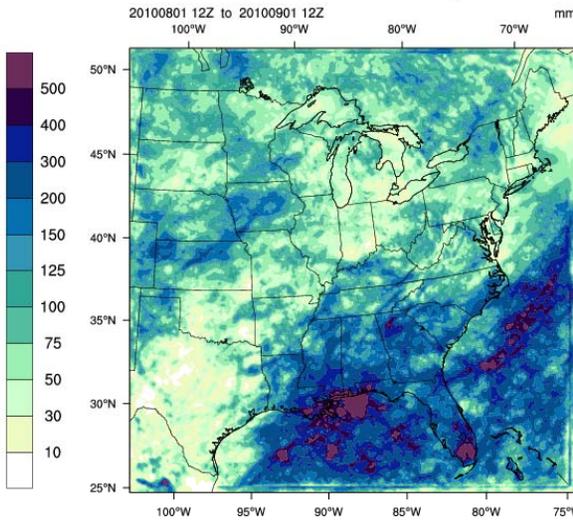


WRF-ARW Accumulated Precipitation



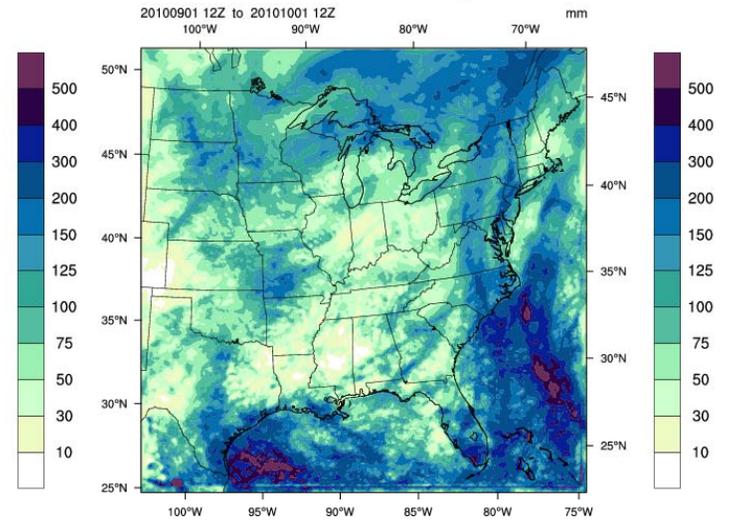
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WRF-ARW Accumulated Precipitation



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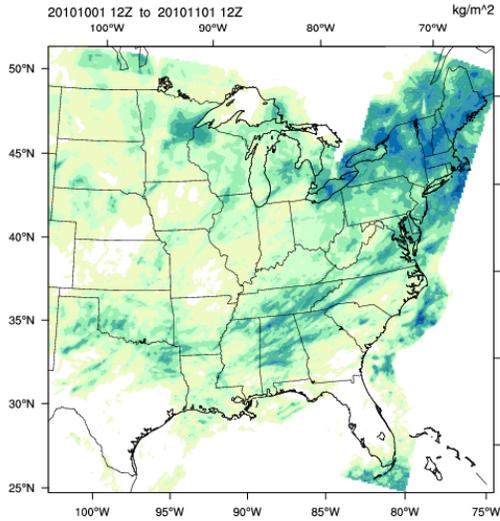
WRF-ARW Accumulated Precipitation



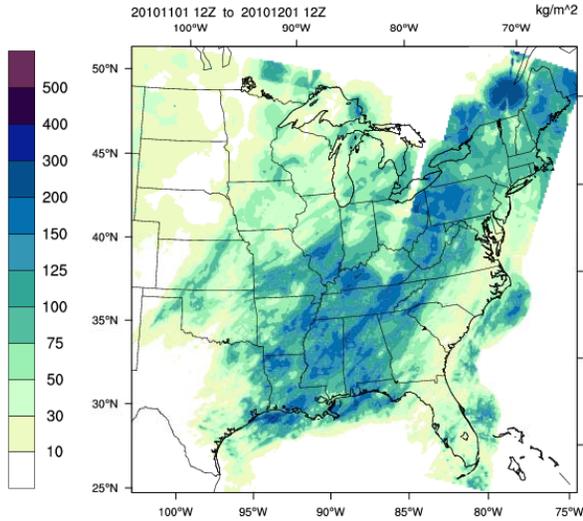
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October – December, 2010

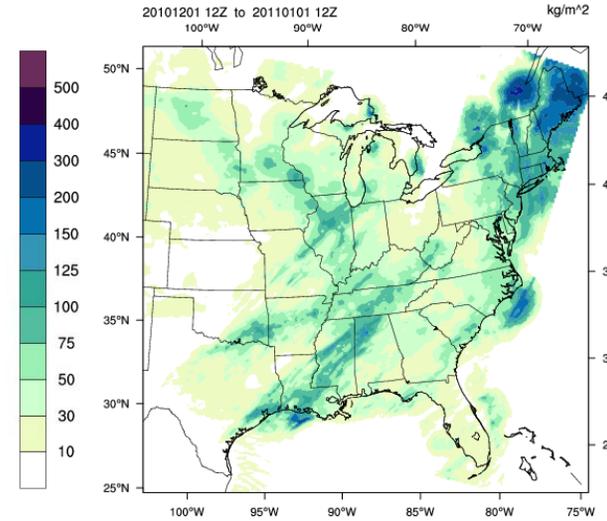
NCEP Stage IV Precipitation Analysis (Accumulated)



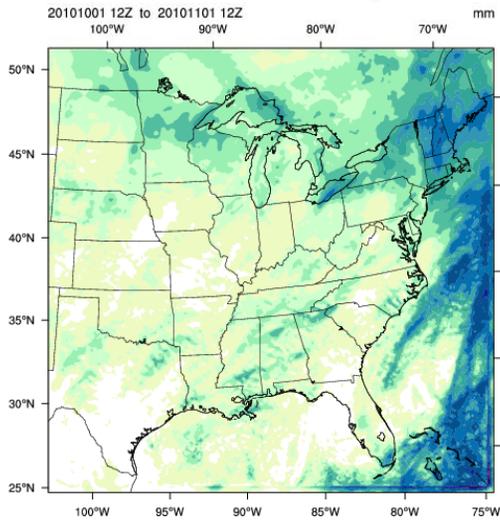
NCEP Stage IV Precipitation Analysis (Accumulated)



NCEP Stage IV Precipitation Analysis (Accumulated)

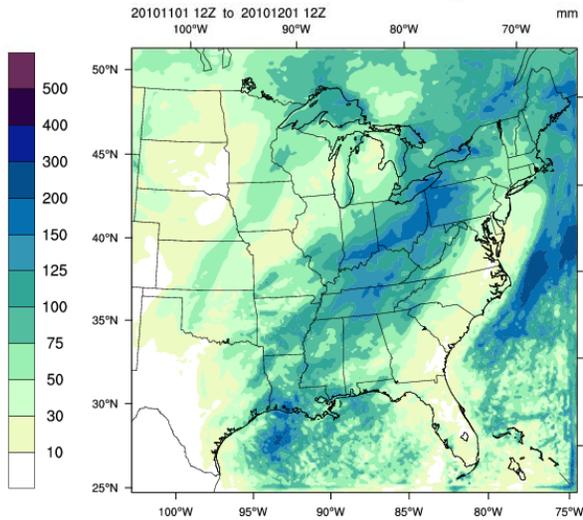


WRF-ARW Accumulated Precipitation



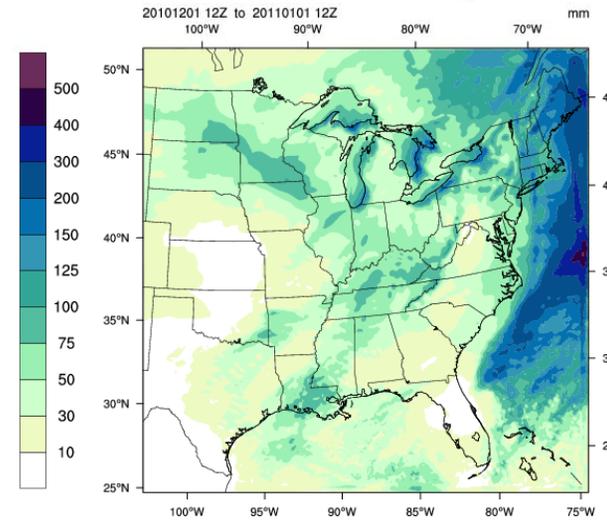
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WRF-ARW Accumulated Precipitation



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WRF-ARW Accumulated Precipitation

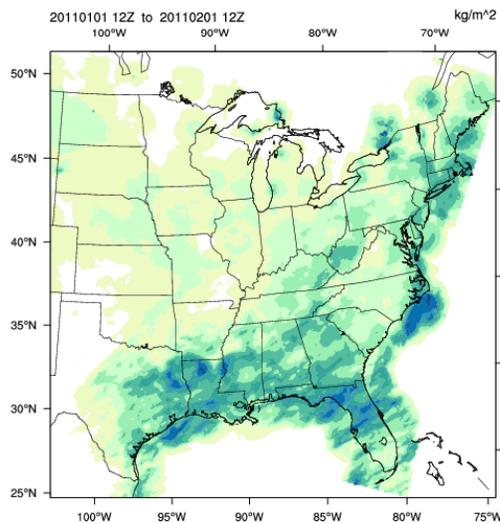


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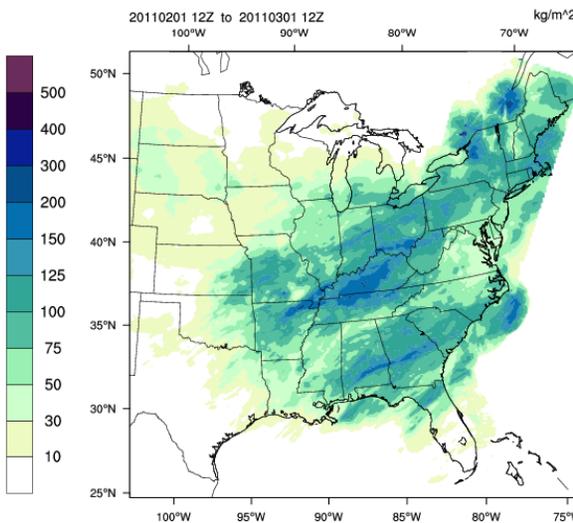


January – March, 2011

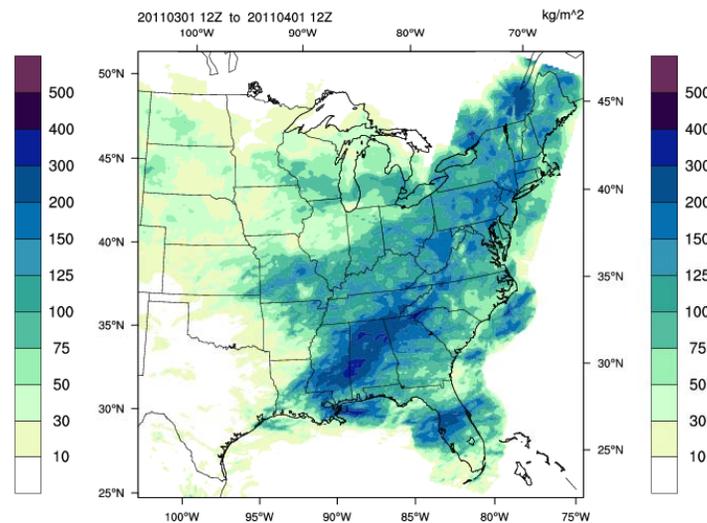
NCEP Stage IV Precipitation Analysis (Accumulated)



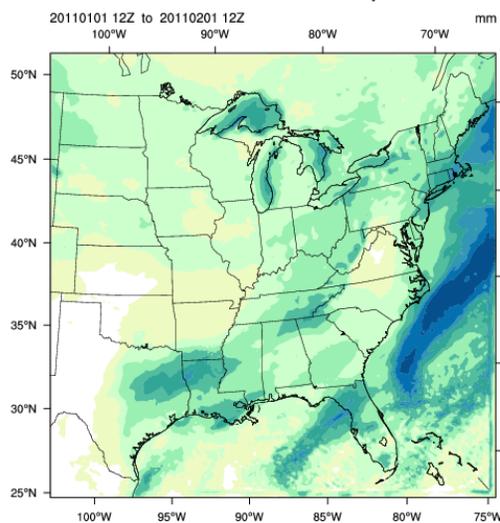
NCEP Stage IV Precipitation Analysis (Accumulated)



NCEP Stage IV Precipitation Analysis (Accumulated)

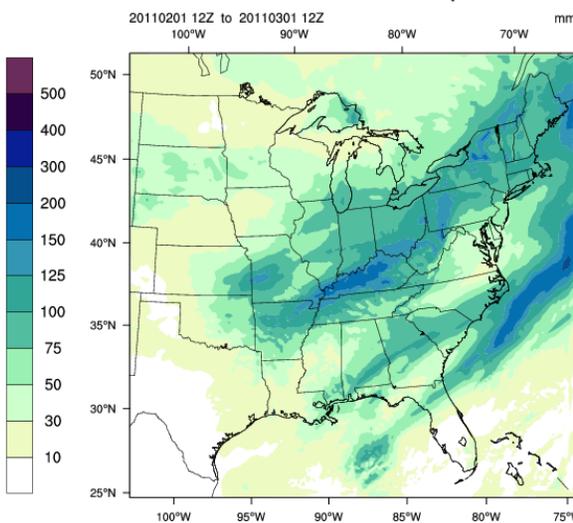


WRF-ARW Accumulated Precipitation



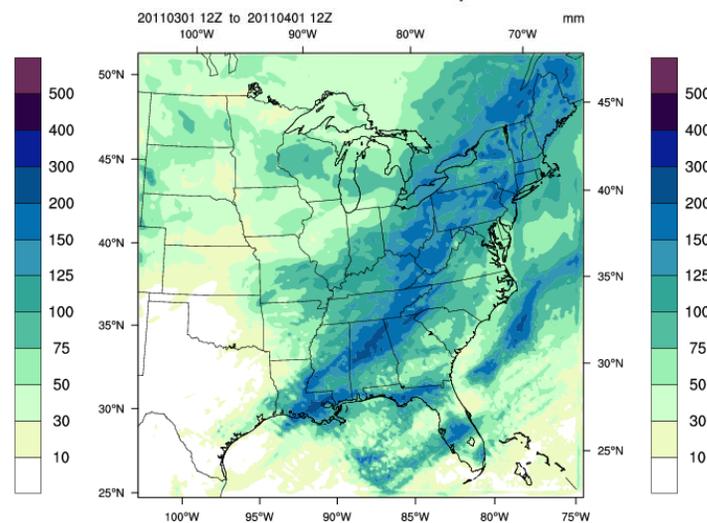
OUTPUT FROM WRF V3.1.1 MODEL
NK: 250 ; NY: 250 ; NZ: 35 ; Res: 12 km ; LSM: 7 ; PBL: 7 ; MP: 10 ; SW: 4 ; LW: 4 ; Cu: 1

WRF-ARW Accumulated Precipitation



OUTPUT FROM WRF V3.1.1 MODEL
NK: 250 ; NY: 250 ; NZ: 35 ; Res: 12 km ; LSM: 7 ; PBL: 7 ; MP: 10 ; SW: 4 ; LW: 4 ; Cu: 1

WRF-ARW Accumulated Precipitation

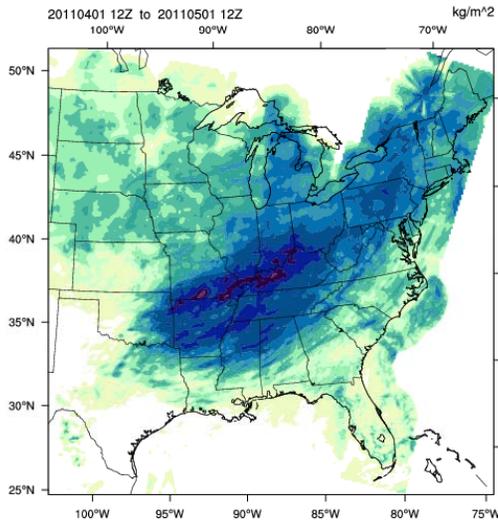


OUTPUT FROM WRF V3.1.1 MODEL
NK: 250 ; NY: 250 ; NZ: 35 ; Res: 12 km ; LSM: 7 ; PBL: 7 ; MP: 10 ; SW: 4 ; LW: 4 ; Cu: 1

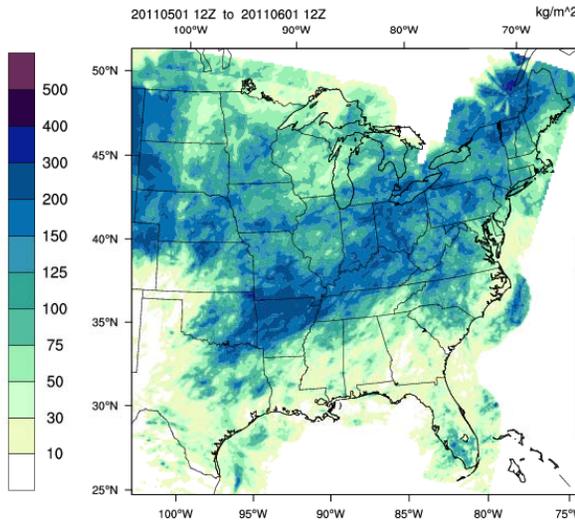


April – June, 2011

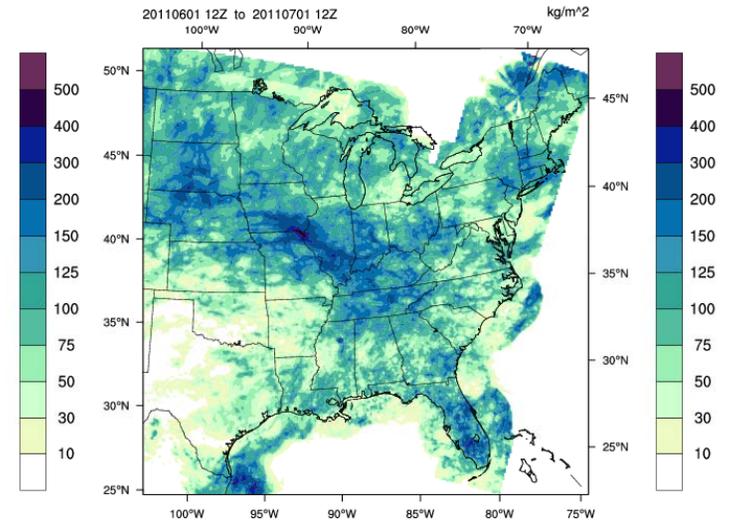
NCEP Stage IV Precipitation Analysis (Accumulated)



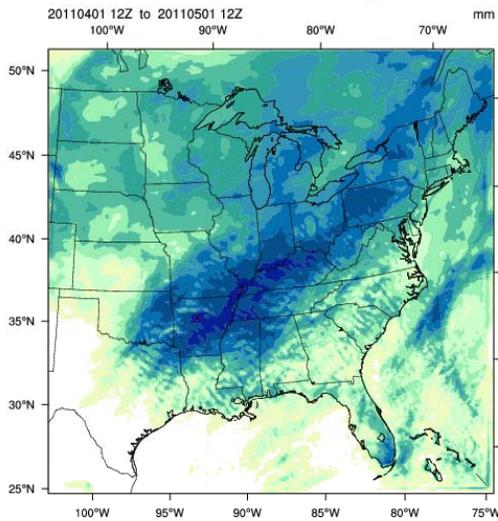
NCEP Stage IV Precipitation Analysis (Accumulated)



NCEP Stage IV Precipitation Analysis (Accumulated)

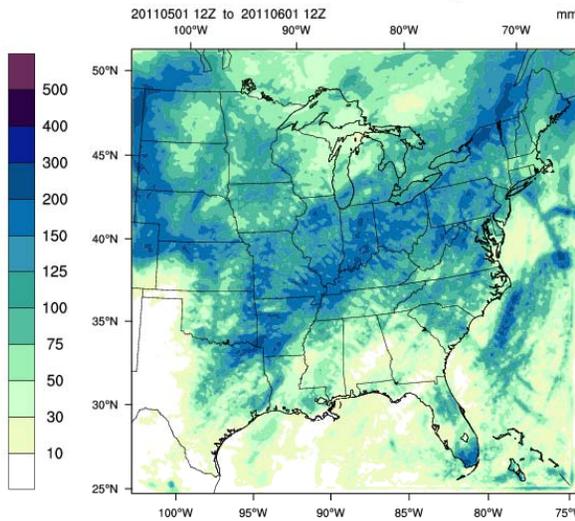


WRF-ARW Accumulated Precipitation



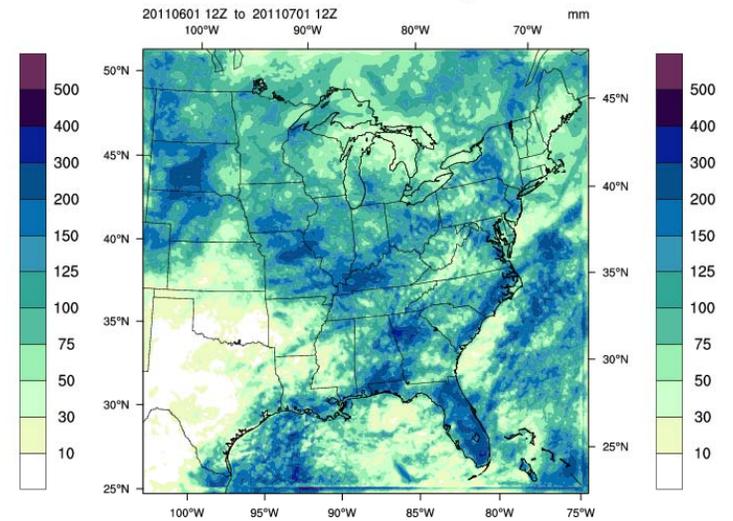
OUTPUT FROM WRF V3.1.1 MODEL
NK: 250 ; NY: 250 ; NZ: 35 ; Res: 12 km ; LSM: 7 ; PBL: 7 ; MP: 10 ; SW: 4 ; LW: 4 ; Cu: 1

WRF-ARW Accumulated Precipitation



OUTPUT FROM WRF V3.1.1 MODEL
NK: 250 ; NY: 250 ; NZ: 35 ; Res: 12 km ; LSM: 7 ; PBL: 7 ; MP: 10 ; SW: 4 ; LW: 4 ; Cu: 1

WRF-ARW Accumulated Precipitation

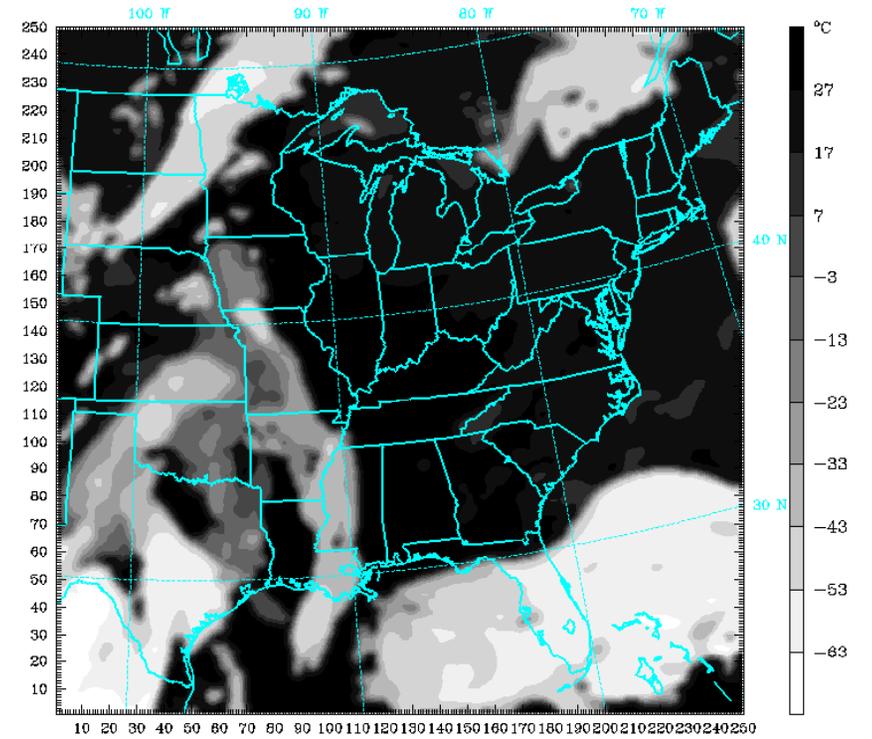
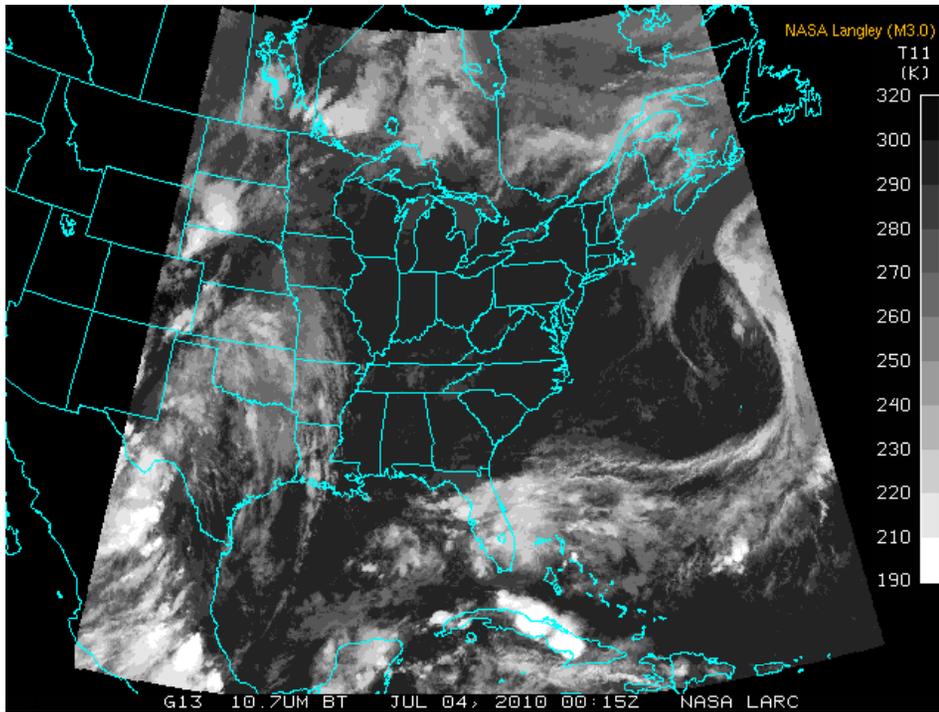


OUTPUT FROM WRF V3.1.1 MODEL
NK: 250 ; NY: 250 ; NZ: 35 ; Res: 12 km ; LSM: 7 ; PBL: 7 ; MP: 10 ; SW: 4 ; LW: 4 ; Cu: 1



July 04, 2010 00Z

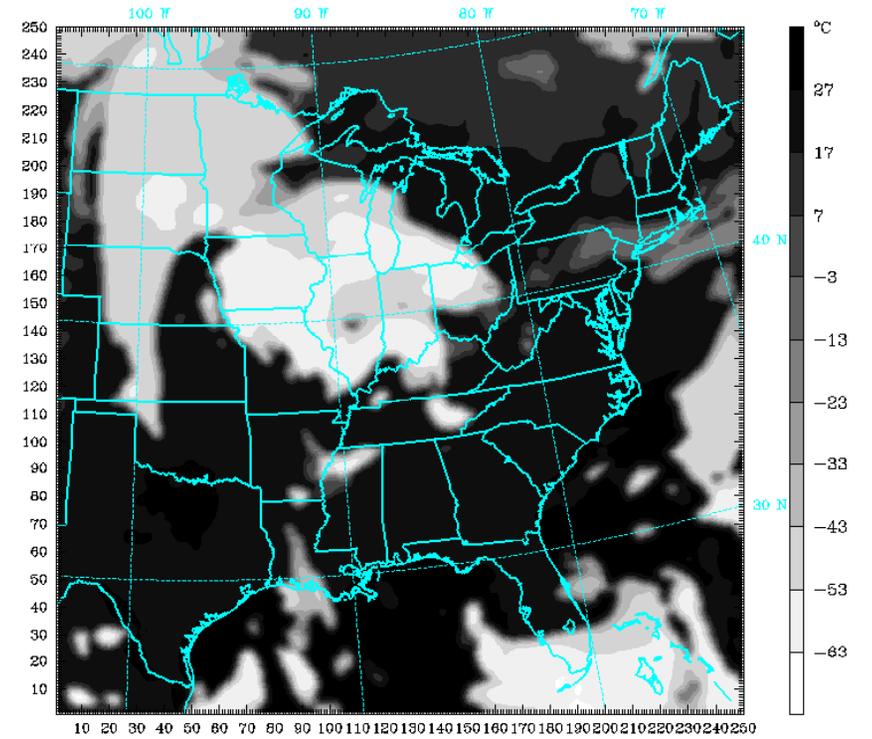
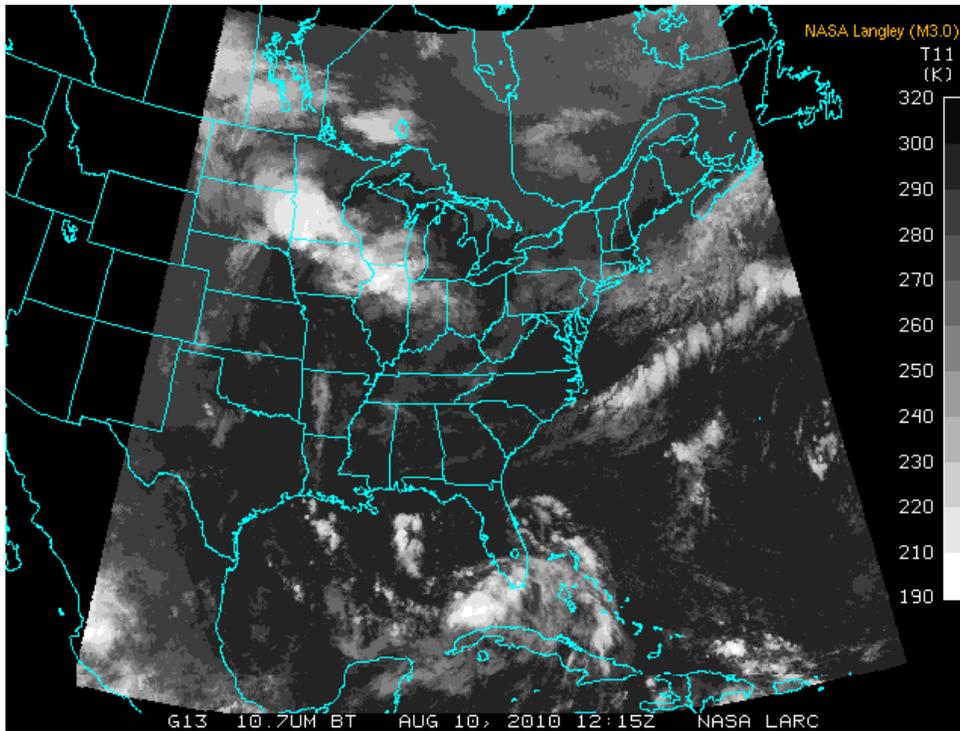
IA DNR 2007 WRF-ARW v3.1.1 Init: 1200 UTC Tue 29 Jun 10
 Fcst: 108.00 h Valid: 0000 UTC Sun 04 Jul 10 (1900 CDT Sat 03 Jul 10)
 Cloud-top temperature sm= 3



Model Info: V3.1.1 KF ACM PBL Morrison PX LSM 12 km, 34 levels, 40 sec
 LW: RRTM SW: RRIMG DIFF: simple KM: 2D Smagor

August 10, 2010 12Z

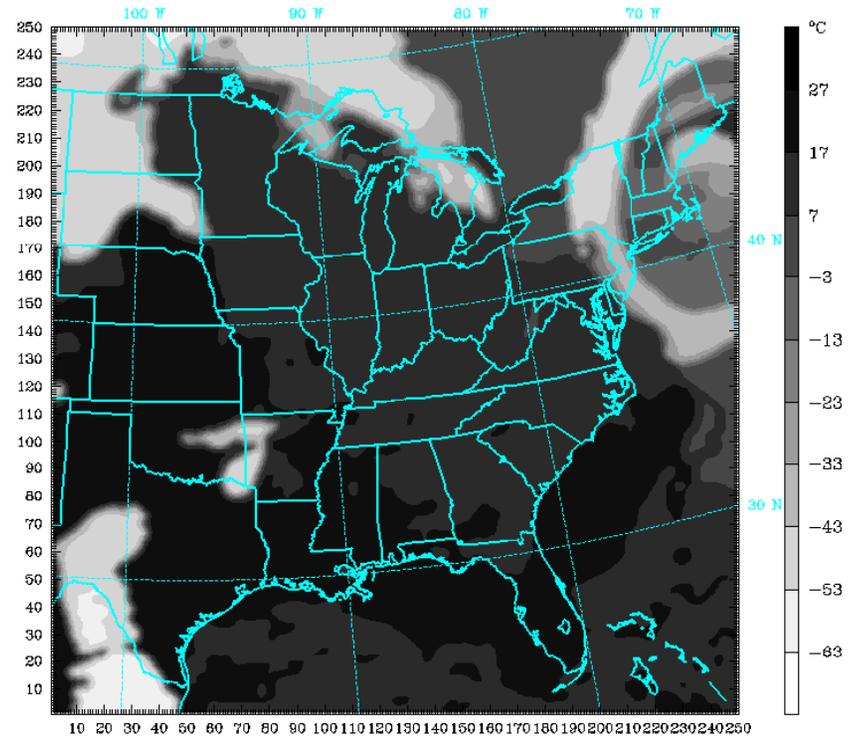
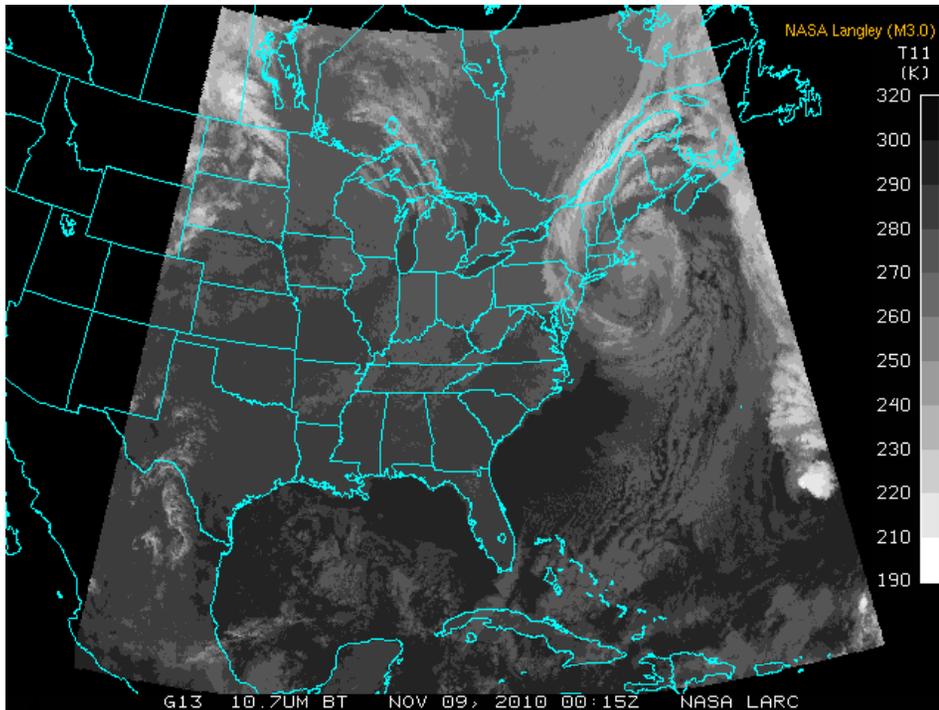
IA DNR 2007 WRF-ARW v3.1.1 Init: 1200 UTC Sun 08 Aug 10
 Fcst: 48.00 h Valid: 1200 UTC Tue 10 Aug 10 (0700 CDT Tue 10 Aug 10)
 Cloud-top temperature sm= 3



Model Info: V3.1.1 KF ACM PBL Morrison PX LSM 12 km, 34 levels, 40 sec
 LW: RRTM SW: RRMG DIFF: simple KM: 2D Smagor

November 09, 2010 00Z

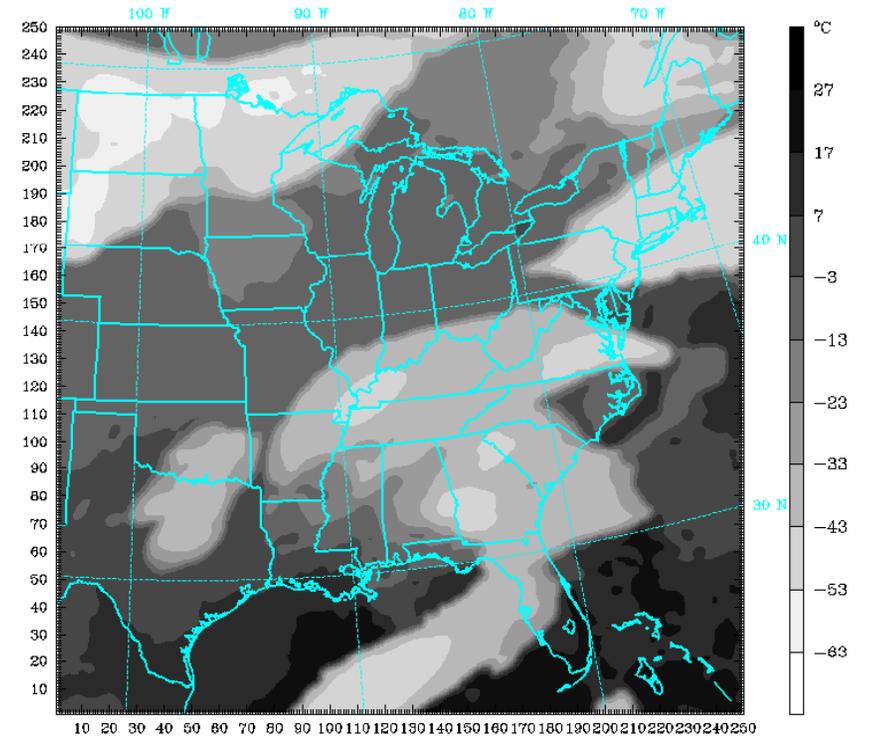
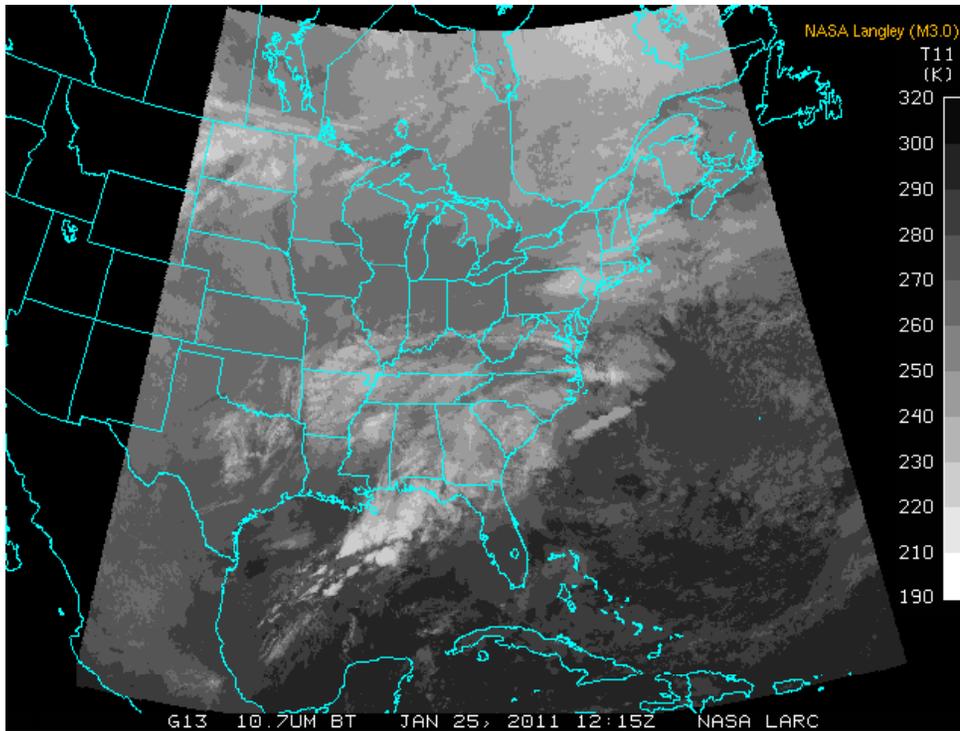
IA DNR 2007 WRF-ARW v3.1.1 Init: 1200 UTC Sat 06 Nov 10
 Fcst: 60.00 h Valid: 0000 UTC Tue 09 Nov 10 (1800 CST Mon 08 Nov 10)
 Cloud-top temperature sm= 3



Model Info: V3.1.1 KF ACM PBL Morrison PX LSM 12 km, 34 levels, 40 sec
 LW: RRTM SW: RRMG DIFF: simple KM: 2D Smagor

January 25, 2011 12Z

IA DNR 2007 WRF-ARW v3.1.1 Init: 1200 UTC Thu 20 Jan 11
 Fcst: 120.00 h Valid: 1200 UTC Tue 25 Jan 11 (0600 CST Tue 25 Jan 11)
 Cloud-top temperature sm= 3



Model Info: V3.1.1 KF ACM PBL Morrison PX LSM 12 km, 34 levels, 40 sec
 LW: RRTM SW: RRIMG DIFF: simple KM: 2D Smagor

Conclusions

- **2 m temperature performance was mixed**
 - Areas of large positive and large negative bias
 - Gross error was generally reasonable
 - Under-prediction in spring and summer
 - Over-prediction in fall and occasionally in winter
 - Largest errors occurred during winter and spring, lowest in the summer

- **10 m wind speed performed well**
 - Some under-prediction occurred in winter and spring
 - Occasional over-prediction in the fall
 - Gross error was consistently low, but worst in spring

Conclusions (Cont.)

- **2 m mixing ratio performed well**
 - Slight over-prediction during the spring and summer
 - Gross errors were lowest in winter; highest in the summer

- **Modeled precipitation showed good agreement**
 - Consistent across the year
 - Spatial patterns well represented
 - Extent and magnitude of precip fields were reasonable
 - Some months showed slight under-prediction of heavy precipitation events

Conclusions (Cont.)

- **Modeled cloud fields agreed well with satellite observations**
- **Performance is very similar to 2007 WRF simulation**