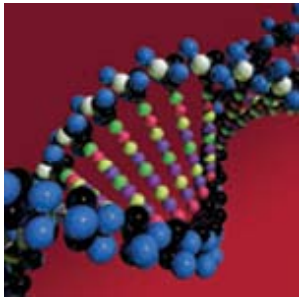
Liberty-Clairton 24-hr $PM_{2.5}$ Attainment Demonstration WRF Modeling



Dennis McNally and Cyndi Loomis
Alpine Geophysics, LLC
Bart Brashers and Robert Hahn
ENVIRON International Corporation

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WRF Modeling

- Introduction
- Model Configuration
- Model Performance Summary
- Supplemental AERMINUTE Analysis

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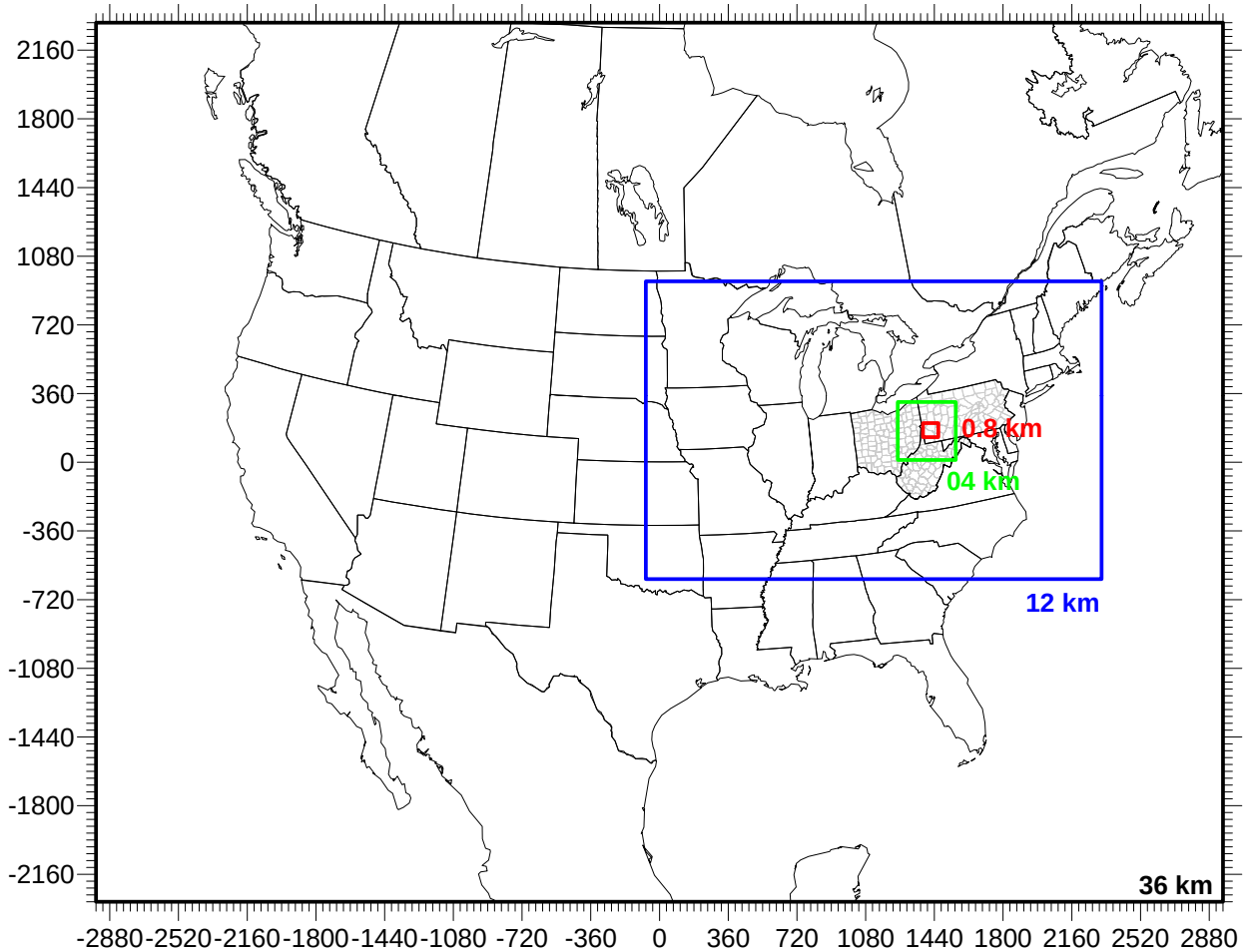
WRF Modeling Domains



ACHD WRF Domain

36 km	164 x 128	(-2952, -2304) to (2952,	2304)
12 km	199 x 130	(-72, -612) to (2316,	948)
04 km	76 x 76	(1248, 12) to (1552,	316)
0.8 km	101 x 91	(1380, 132) to (1460.8,	204.8)

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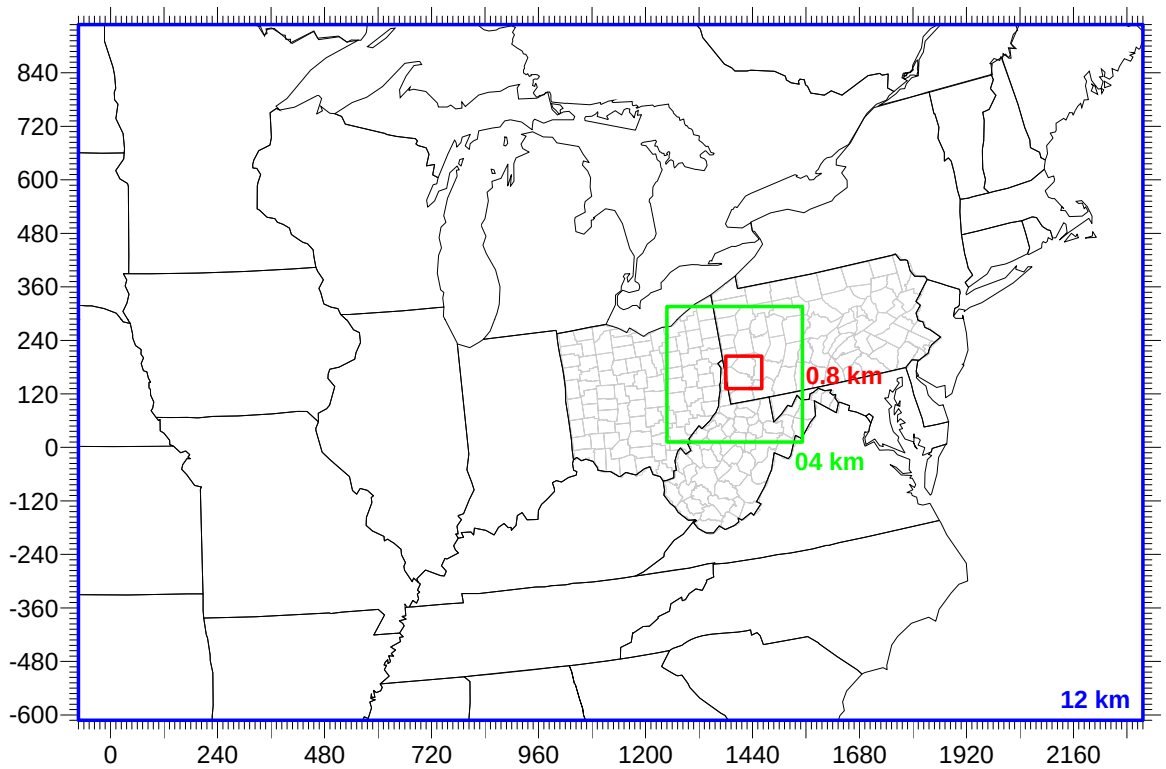
WRF Modeling Domains



ACHD WRF Domain

36 km	164 x 128	(-2952, -2304) to (2952, 2304)
12 km	199 x 130	(-72, -612) to (2316, 948)
04 km	76 x 76	(1248, 12) to (1552, 316)
0.8 km	101 x 91	(1380, 132) to (1460.8, 204.8)

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WRF Vertical Structure

Level	Eta	Height	dZ	Level	Eta	Height	dZ
1	1	0.0		19	0.8	1742.2	373.1
2	0.9985	12.0	12.0	20	0.76	2129.7	387.6
3	0.997	24.1	12.0	21	0.72	2533.1	403.3
4	0.995	40.1	16.1	22	0.68	2953.7	420.6
5	0.993	56.2	16.1	23	0.64	3393.4	439.6
6	0.991	72.4	16.1	24	0.6	3854.1	460.7
7	0.988	96.6	24.2	25	0.55	4463.3	609.2
8	0.985	120.9	24.3	26	0.5	5114.9	651.6
9	0.98	161.5	40.6	27	0.45	5816.1	701.2
10	0.97	243.2	81.7	28	0.4	6576.3	760.2
11	0.96	325.6	82.4	29	0.35	7407.9	831.6
12	0.95	408.6	83.0	30	0.3	8327.8	919.9
13	0.94	492.3	83.7	31	0.25	9360.1	1032.3
14	0.93	576.6	84.4	32	0.2	10541.2	1181.1
15	0.91	747.5	170.9	33	0.15	11929.7	1388.5
16	0.89	921.2	173.8	34	0.1	13630.3	1700.6
17	0.87	1098.0	176.8	35	0.06	15355.1	1724.8
18	0.84	1369.1	271.1	36	0.027	17204.9	1849.7

WRF Initialization

- Model initialization
  - 12km North American Model (NAM) 6-hourly initialization fields
  - 1/12th Degree daily RTG Sea Surface Temperature (SST)

WRF Physics Options

- Microphysics: WRF Single-Moment 3-class scheme
- MYJ Planetary Boundary Layer (TKE Based)
- NOAH Land Surface Model: includes fractional snow cover and frozen soil physics
- RRTMG longwave and shortwave radiation
- Cumulus Physics: Kain-Fritch (36 & 12 km only)

WRF Run Options

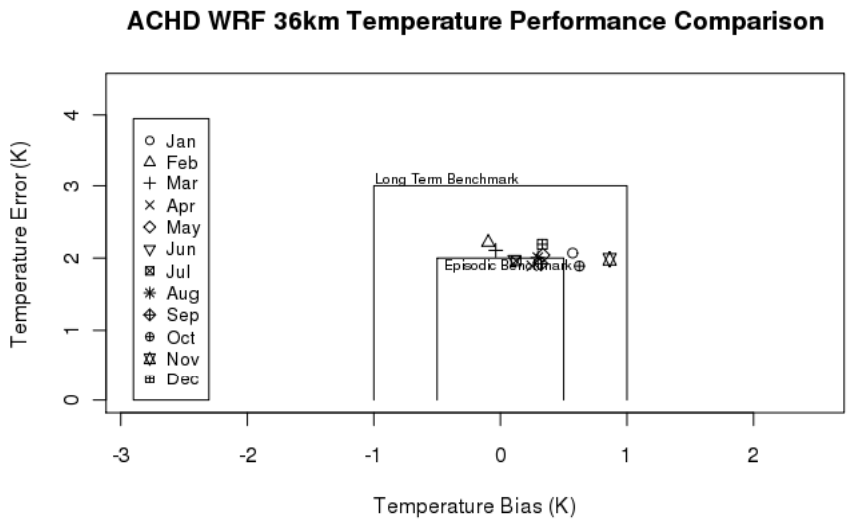
- Simulation Period

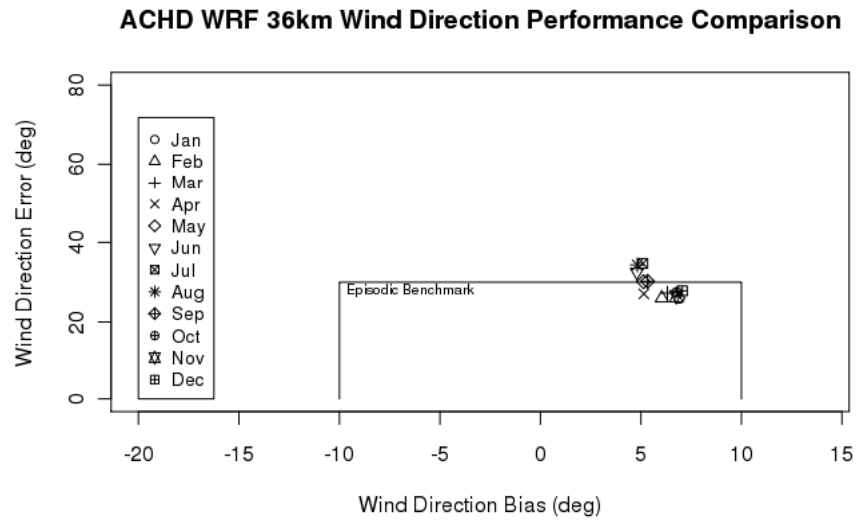
- Model reinitialized every 5-days
  - 12-hour spin-up each segment
- Four Dimensional Data Assimilation
  - Analysis FDDA (12km NAM) on 36/12 km
  - Obs. Nudging to surface winds in 4km
  - No nudging in 800m.

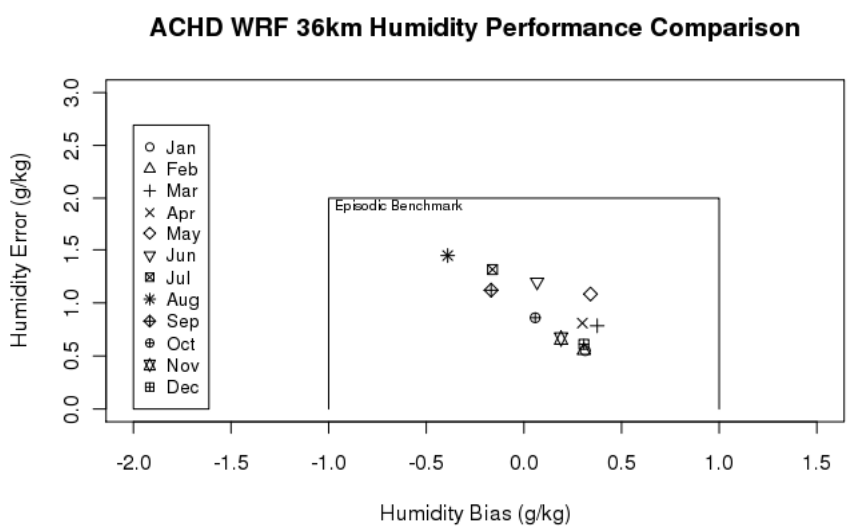
Statistical Comparisons

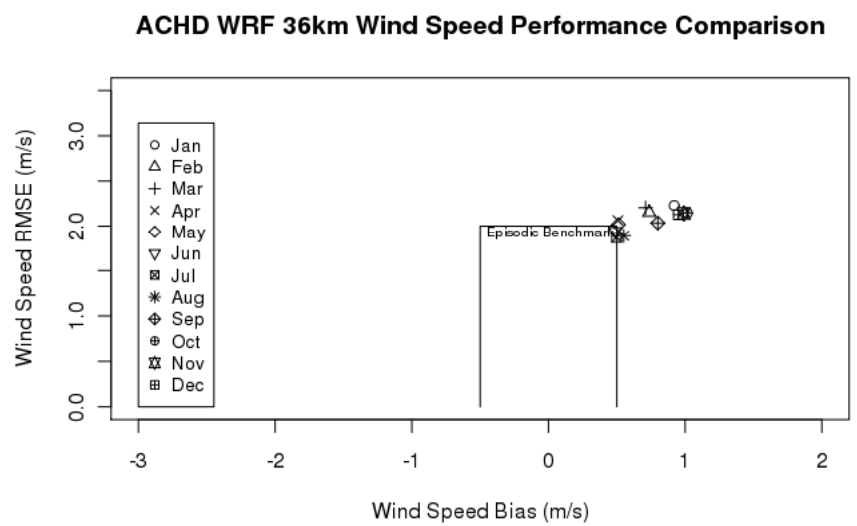
- Report Summarizes Statistics for each domain on a state-by-state basis
- Soccerplots
  - Temperature
  - Moisture
  - Wind Direction
  - Wind Speed

36 km Soccerplots

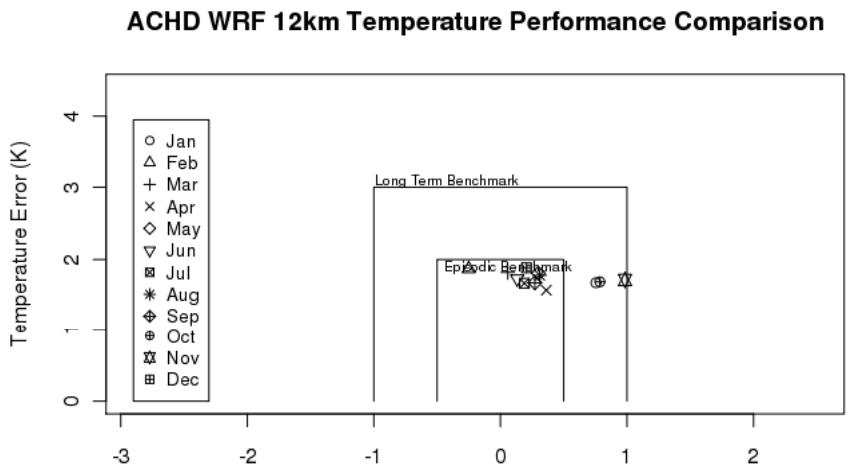


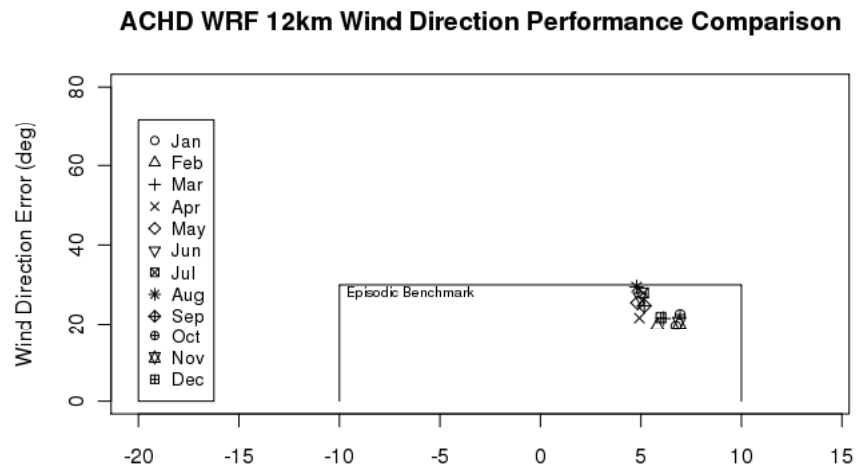


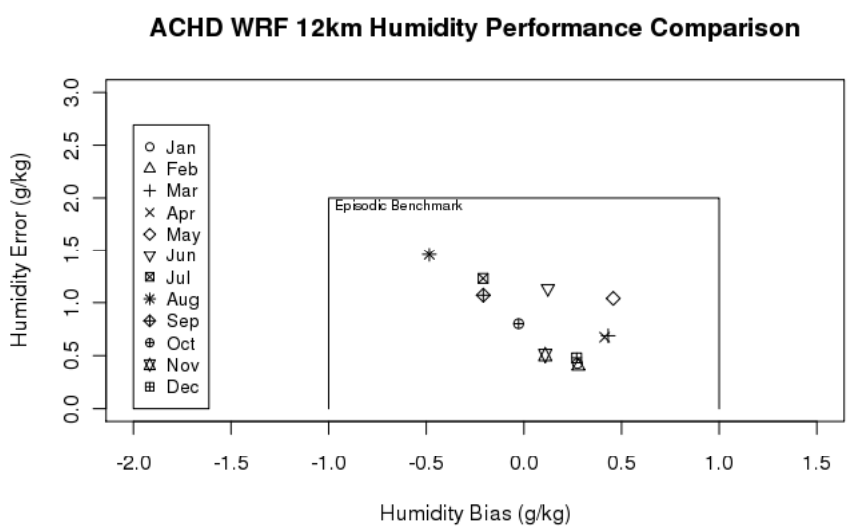


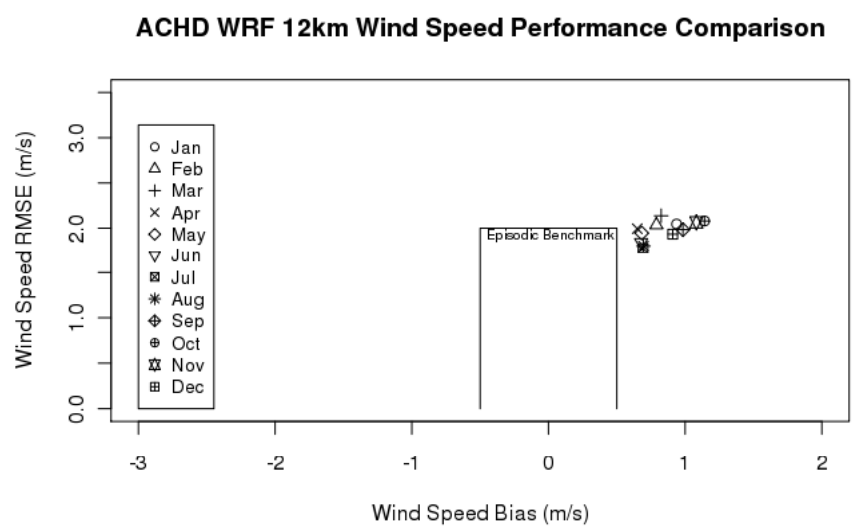


12 km Soccerplots





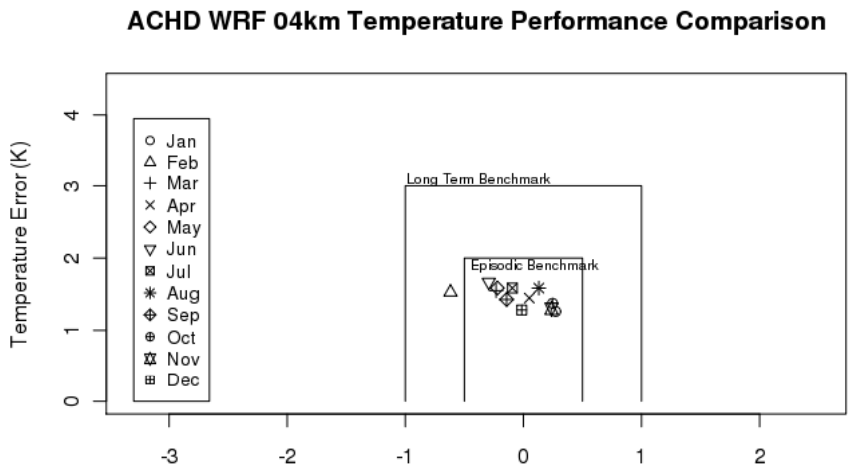


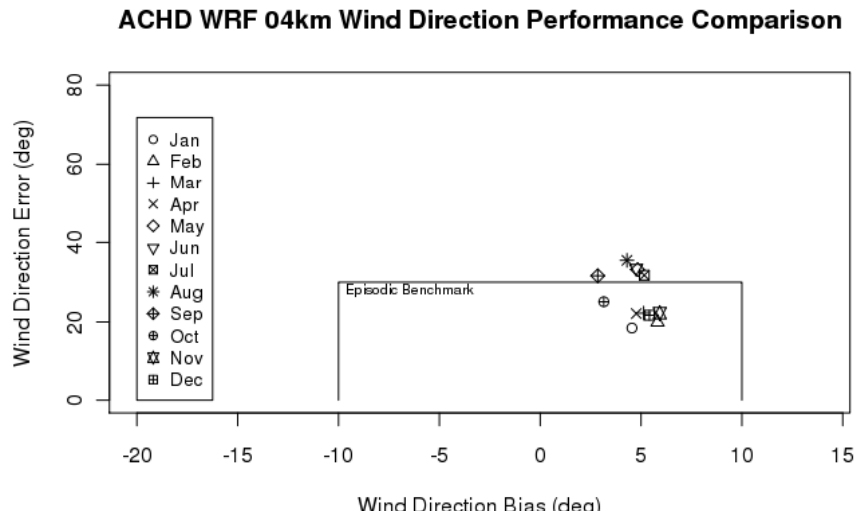


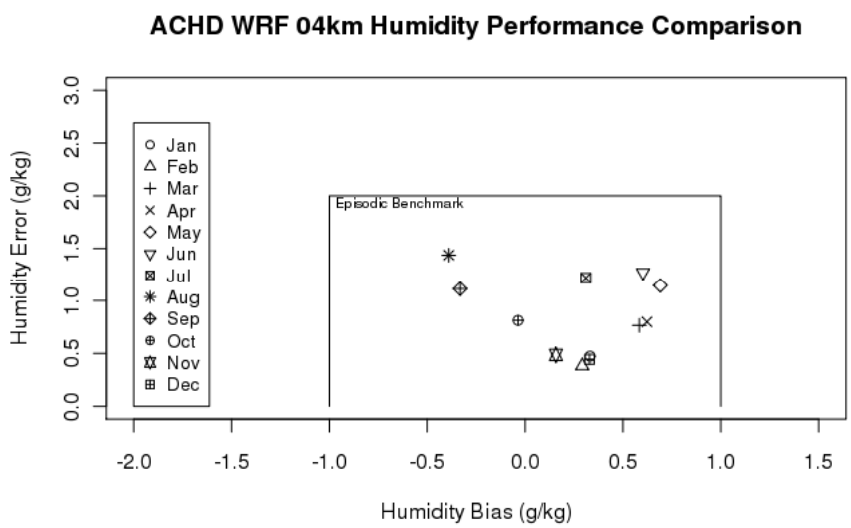
ALPINE GEOPHYSICS

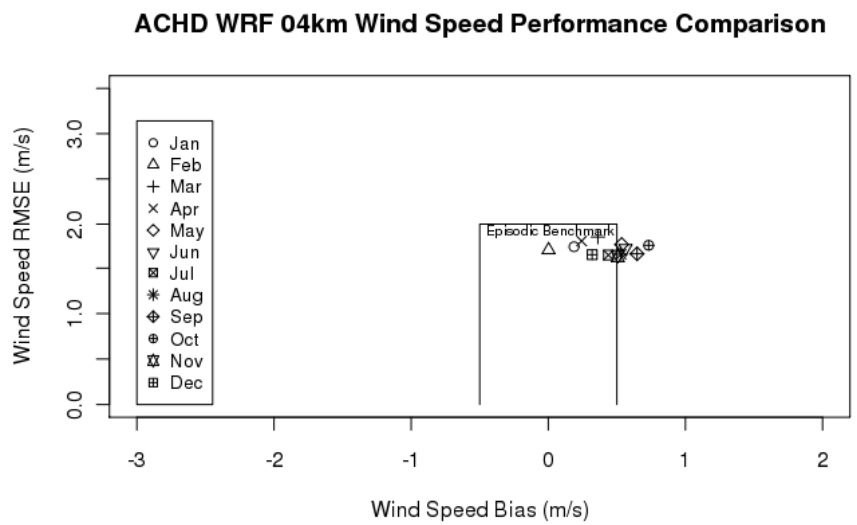
ENVIRON

4 km Soccerplots

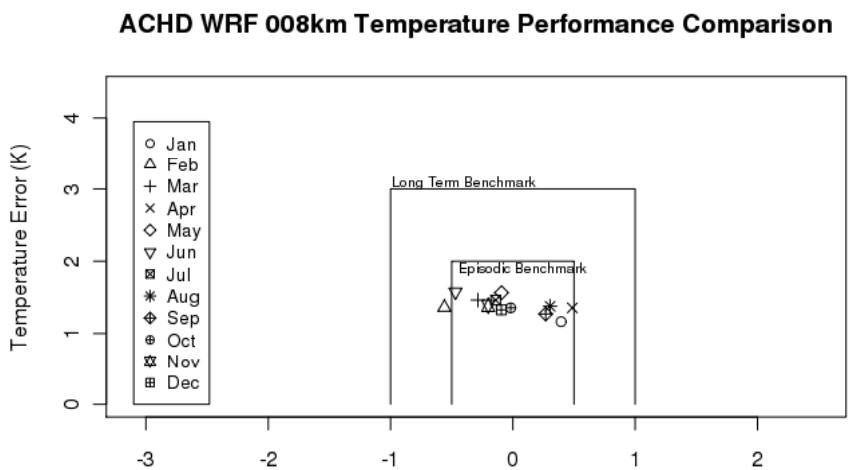


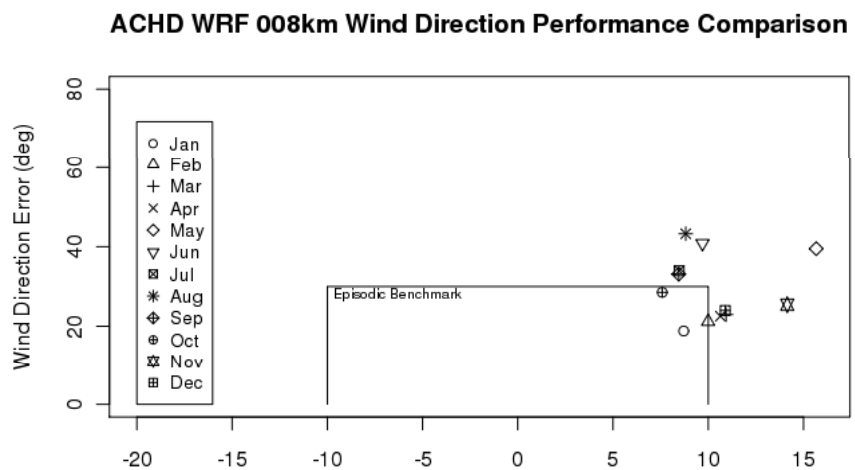


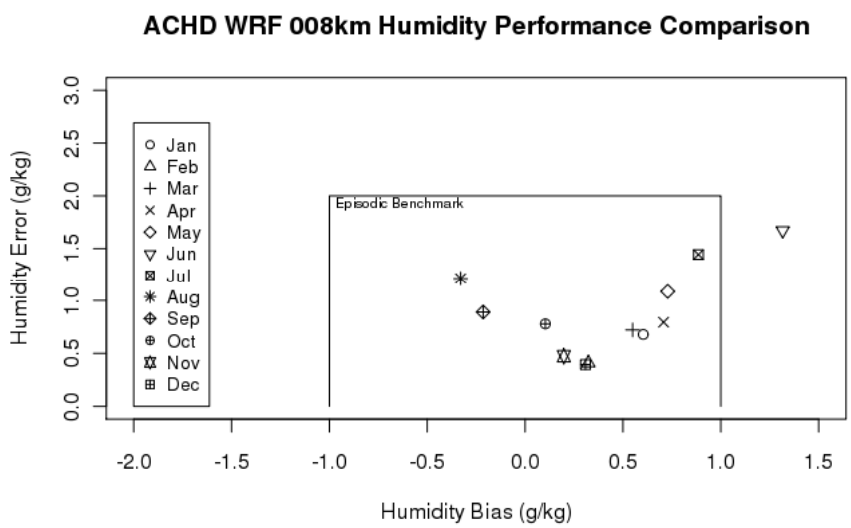


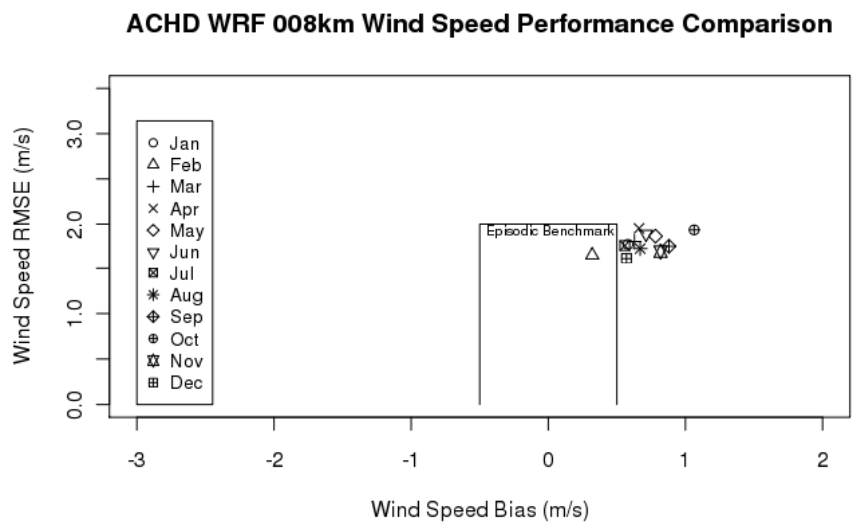


800 m Soccerplots









Statistical Conclusions

- Temperature
  - Model within long-term benchmark on all 4 grids
  - Model nearly always within episodic benchmark
- Humidity
  - Model nearly always within episodic benchmark
- Wind Direction
  - At or near benchmark for 36/12/4 km grids
  - Direction well outside benchmark in 800 m grid
    - Only 3 observation sites
    - Often seen with finer grid spacings
- Wind Speed
  - Model systematically overestimating winds by .5 to 1 m/s
  - Could be calms in observations (0.0 speeds treated as calm)

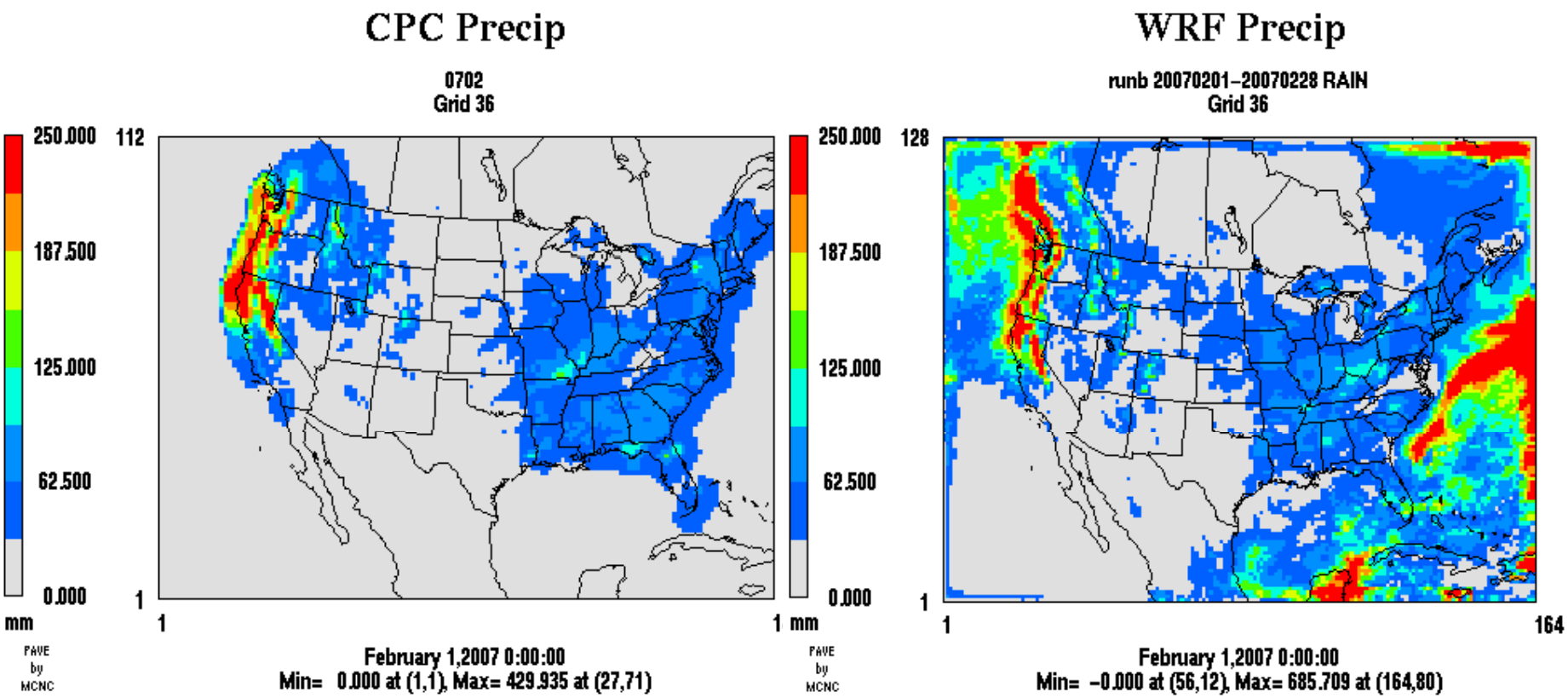
Qualitative Comparison

- Precipitation
- Wind Vectors

ALPINE GEOPHYSICS

ENVIRON

Precipitation
36km February



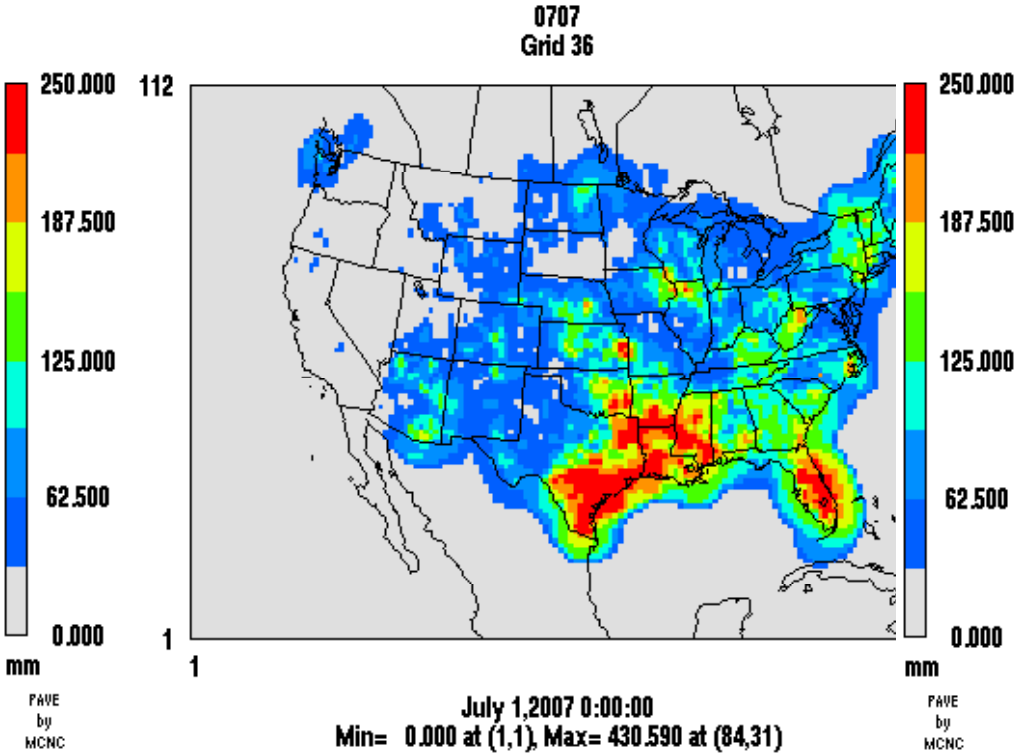
NOTE: CPC Analysis does not extend off-shore

ALPINE GEOPHYSICS

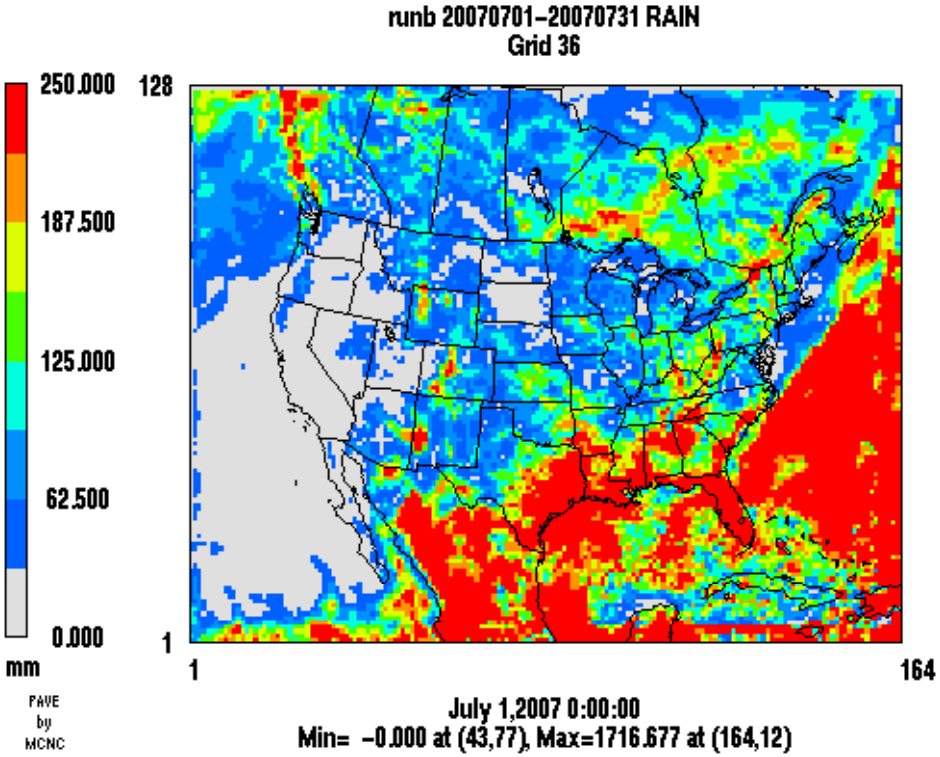
ENVIRON

Precipitation
36km July

CPC Precip



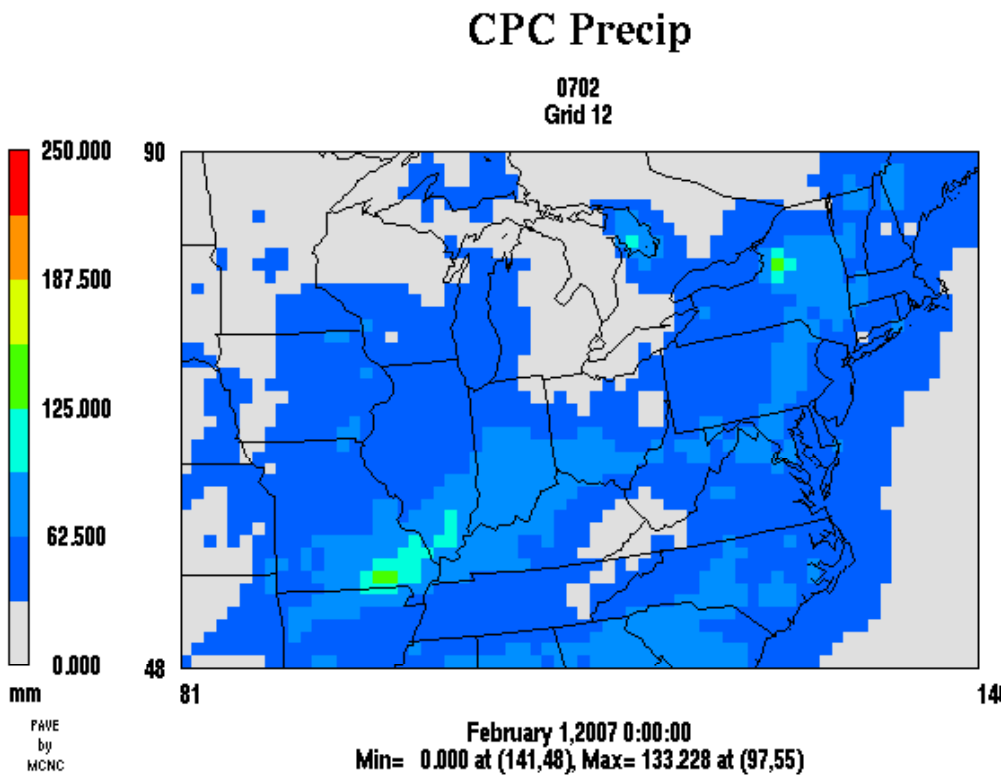
WRF Precip

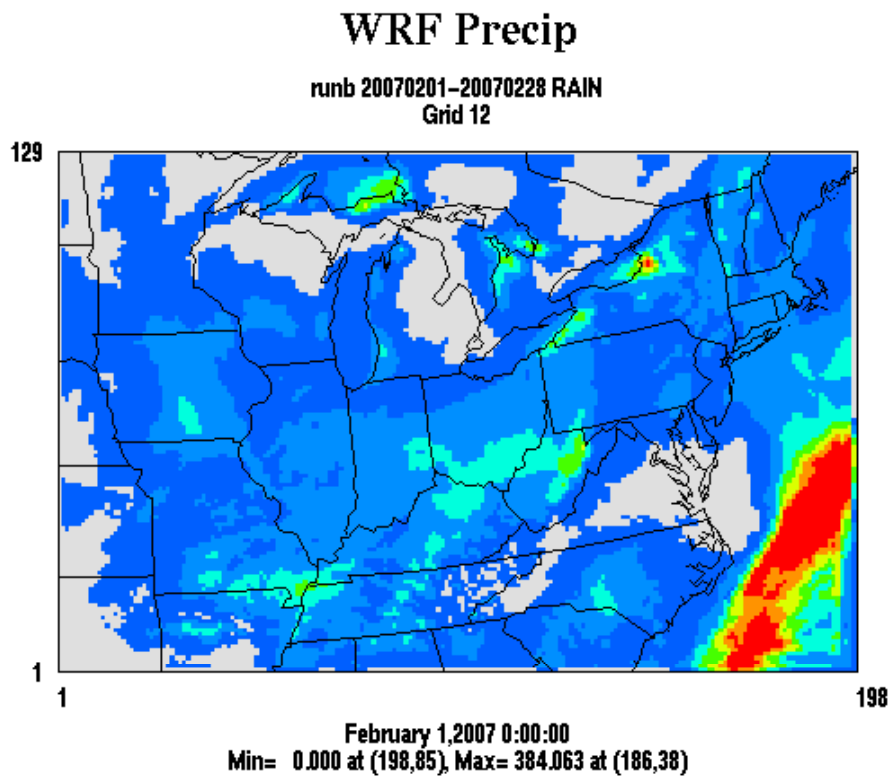


ALPINE GEOPHYSICS

ENVIRON

Precipitation
12 km February

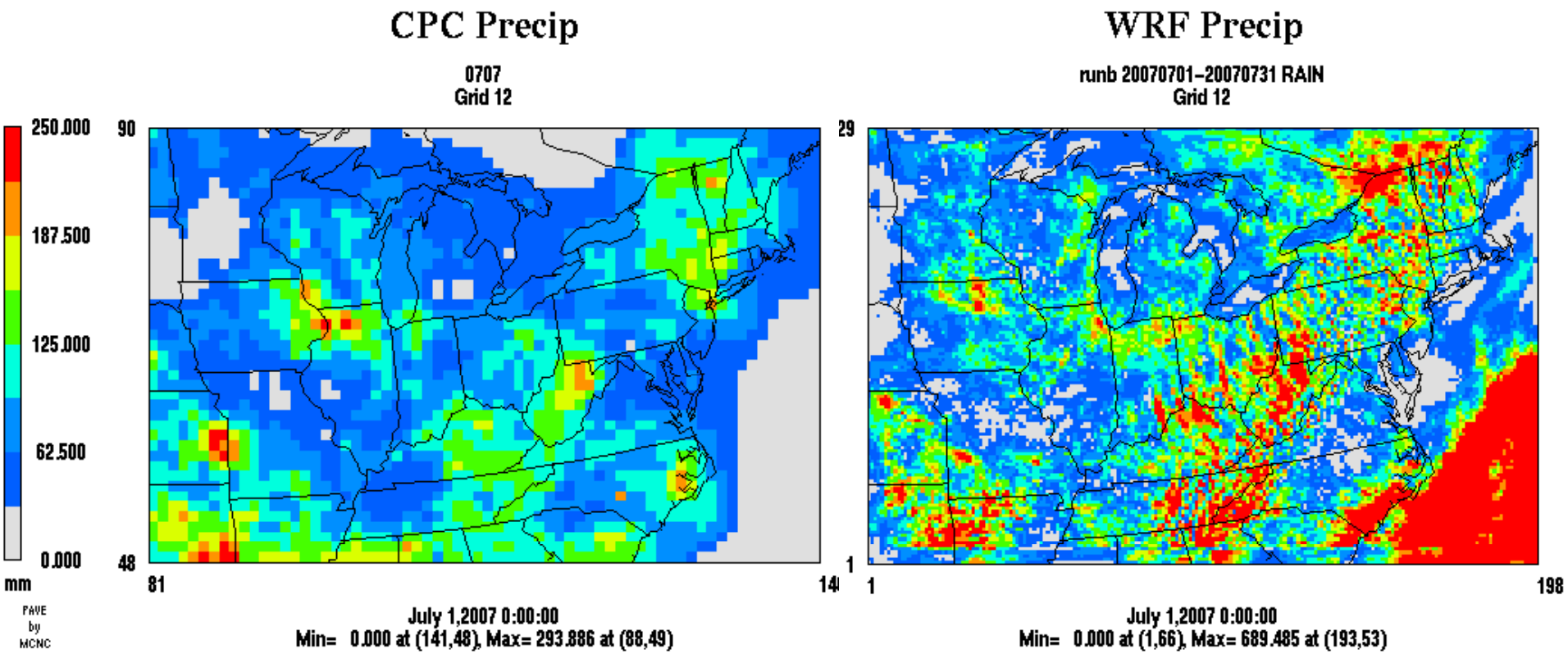




ALPINE GEOPHYSICS

ENVIRON

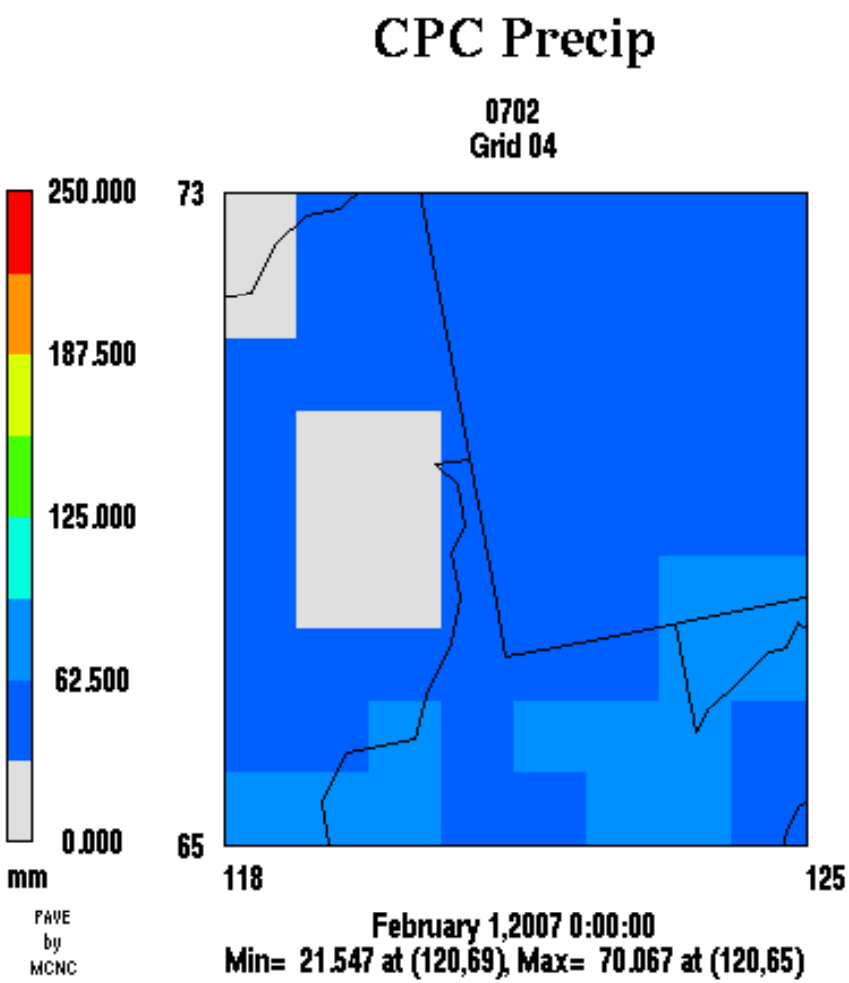
Precipitation
12 km July

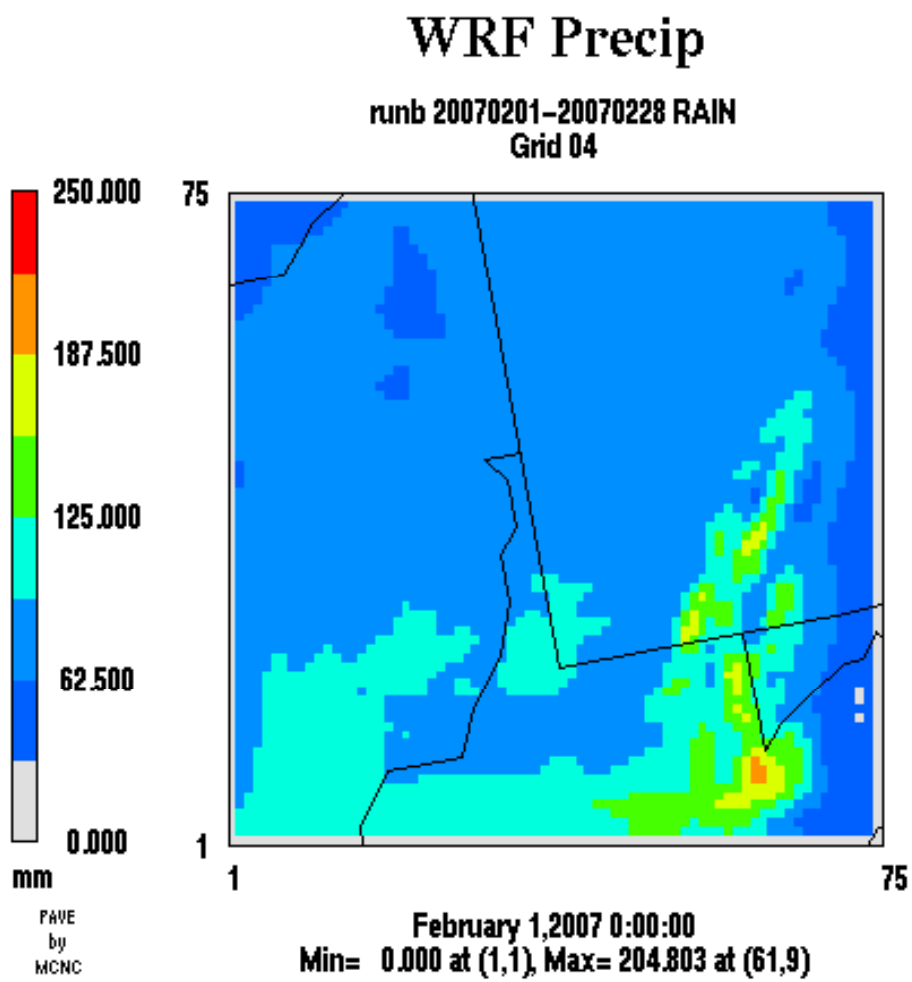


ALPINE GEOPHYSICS

ENVIRON

Precipitation
4 km February

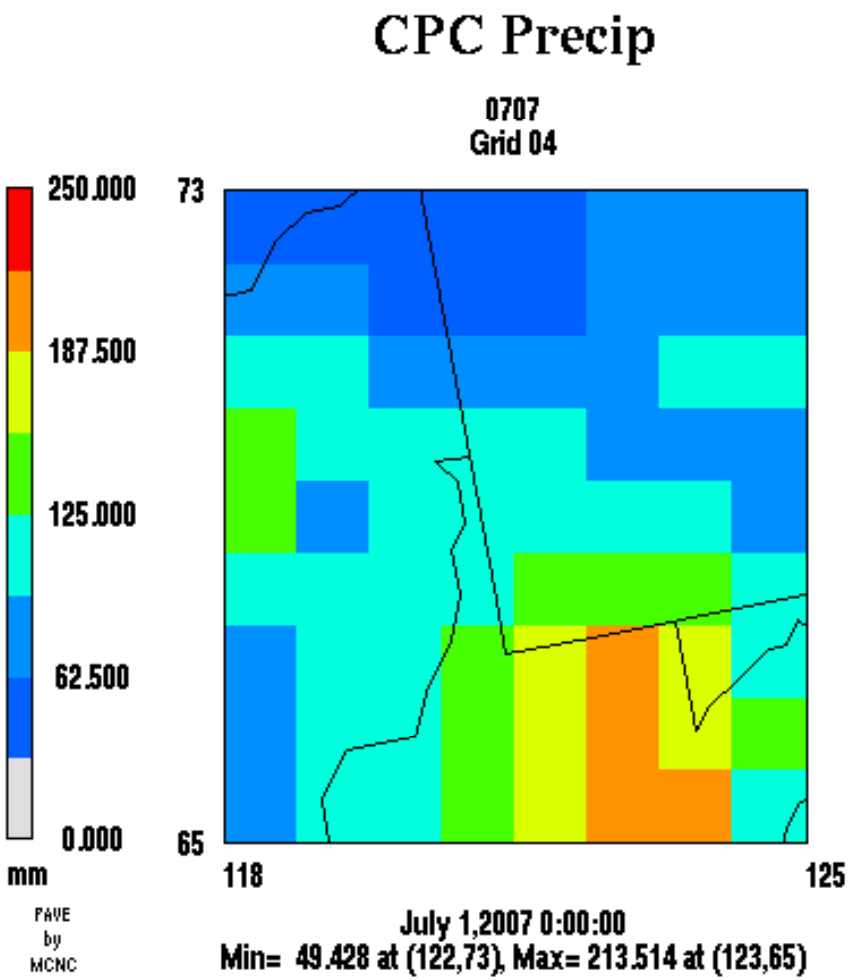


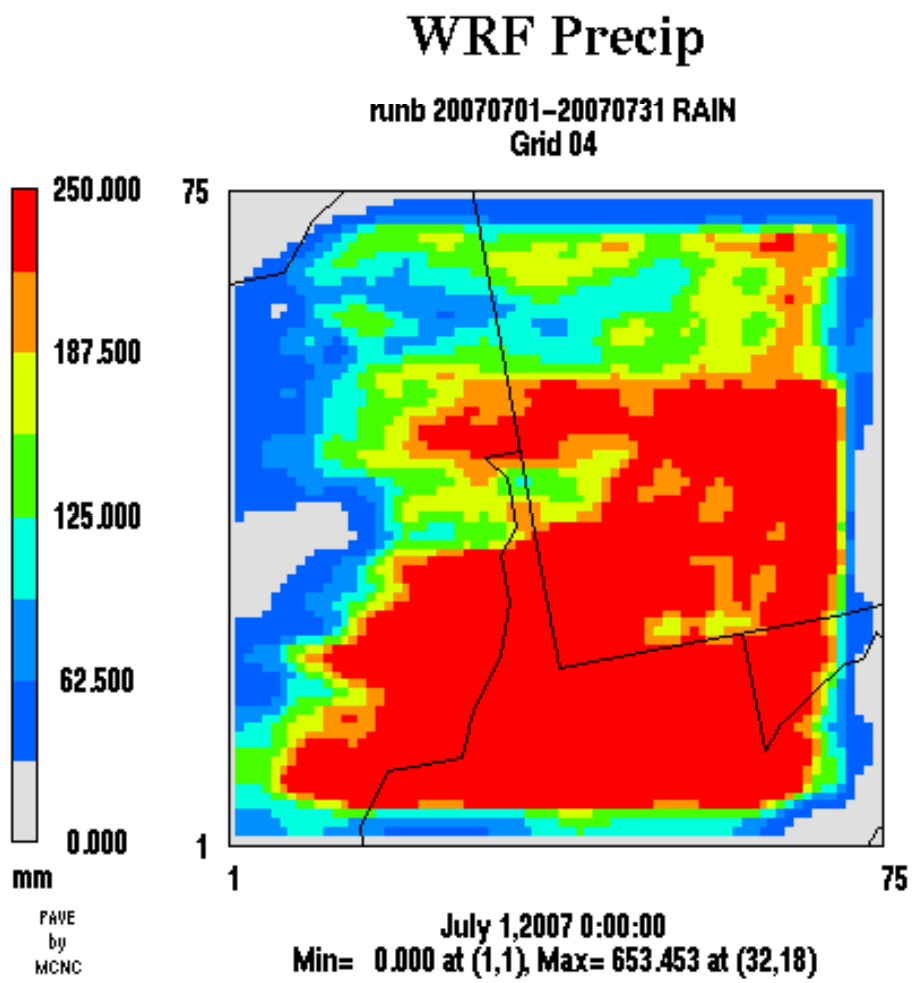


ALPINE GEOPHYSICS

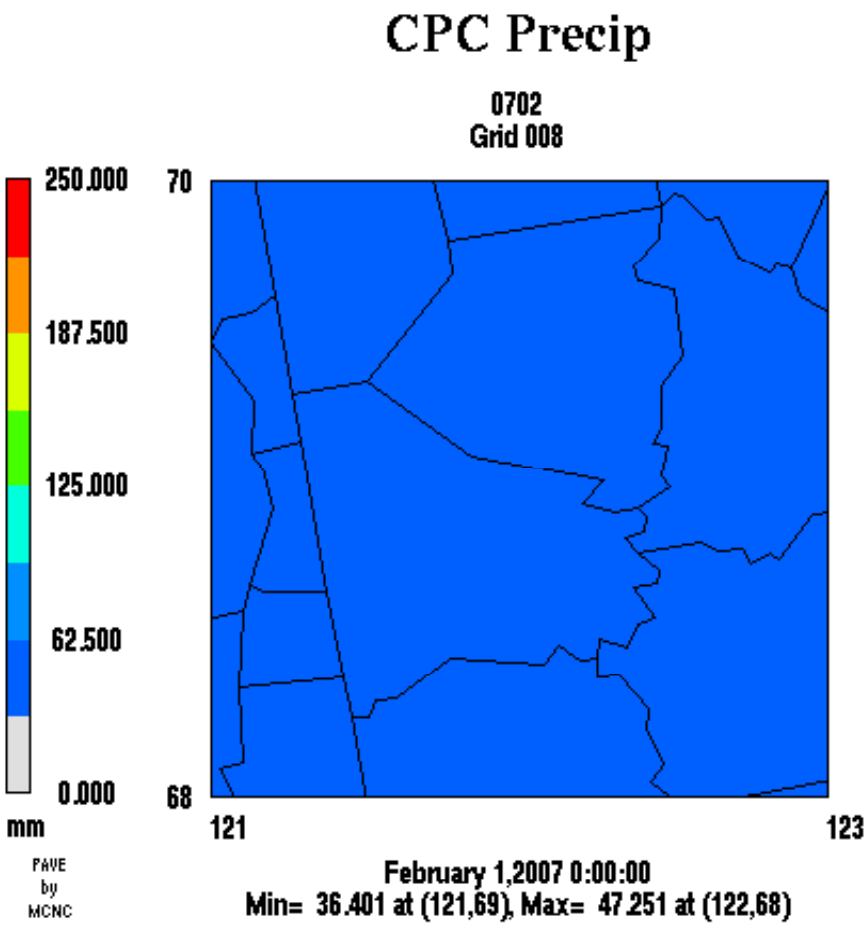
ENVIRON

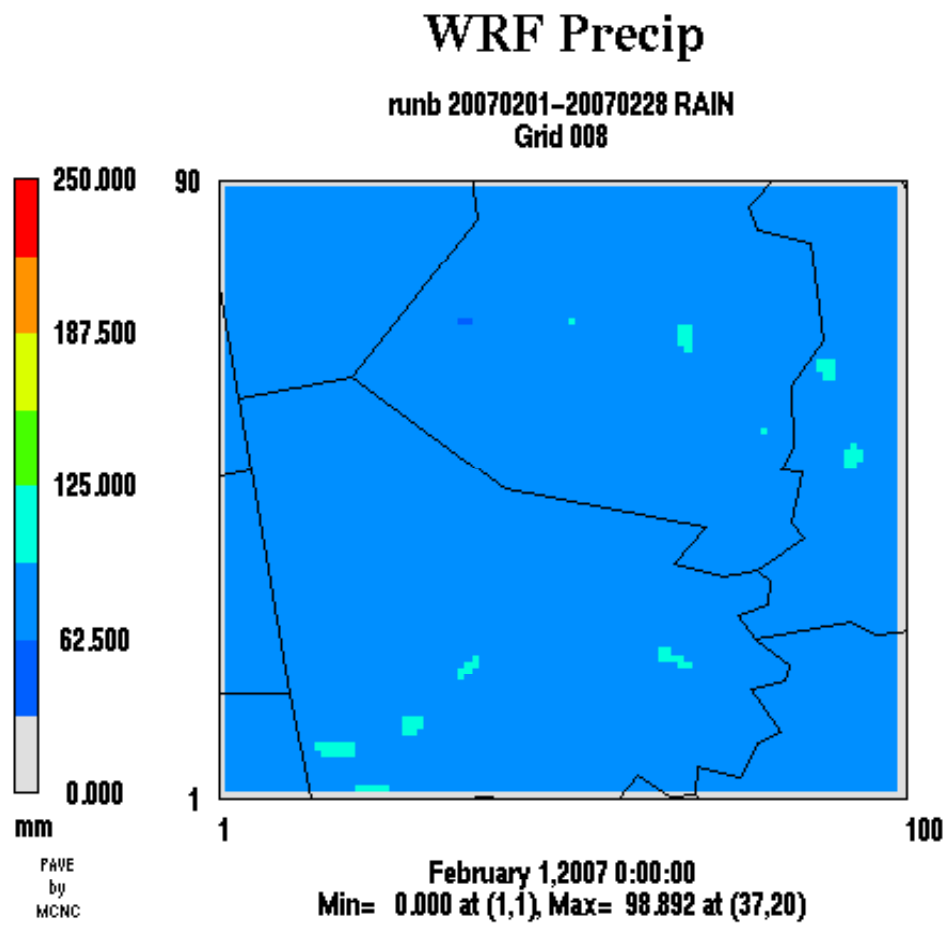
Precipitation
4 km July





Precipitation
800 m February

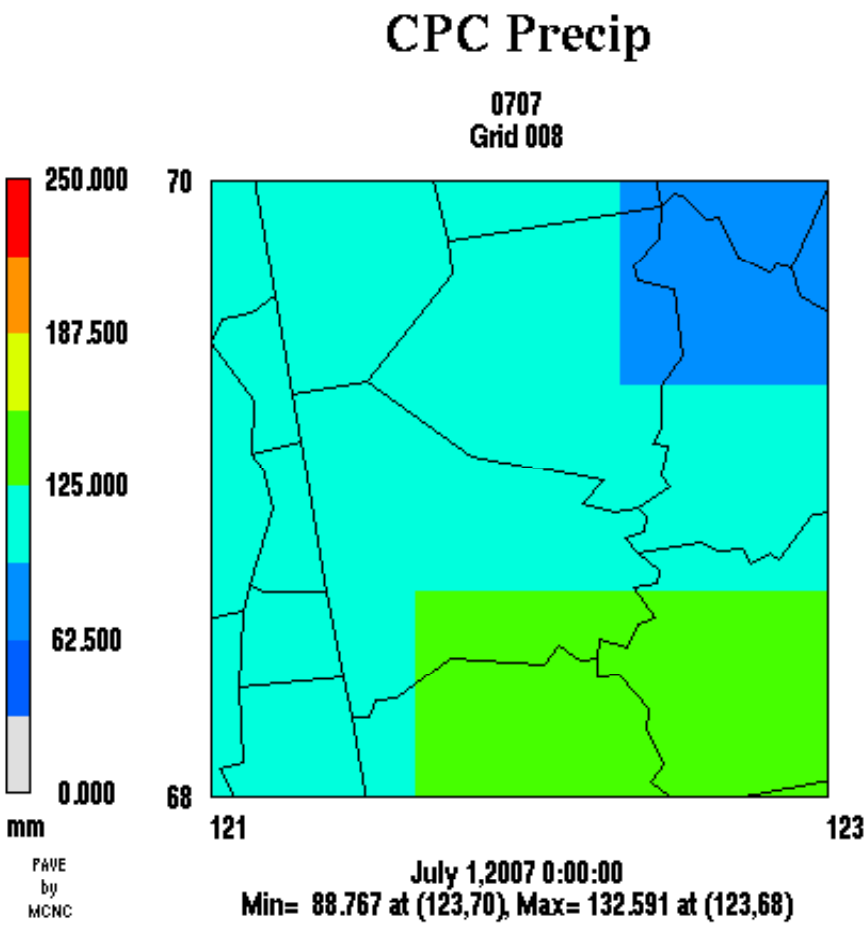


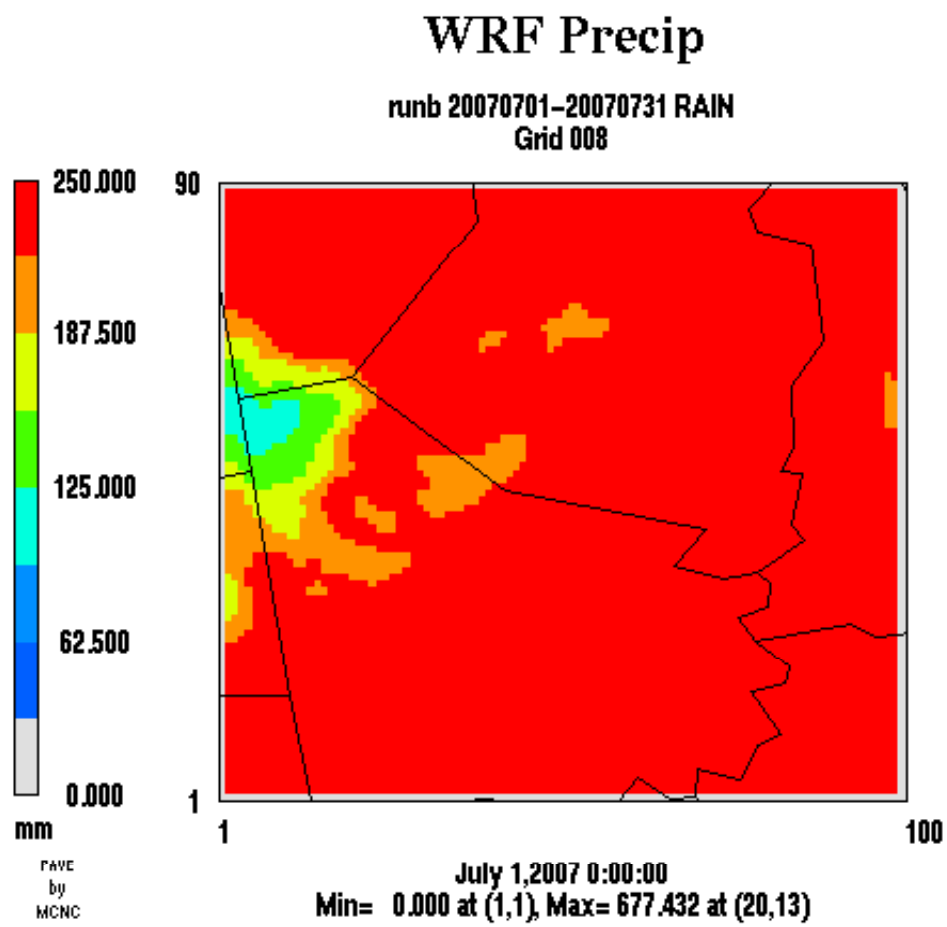


ALPINE GEOPHYSICS

ENVIRON

Precipitation
800 m July

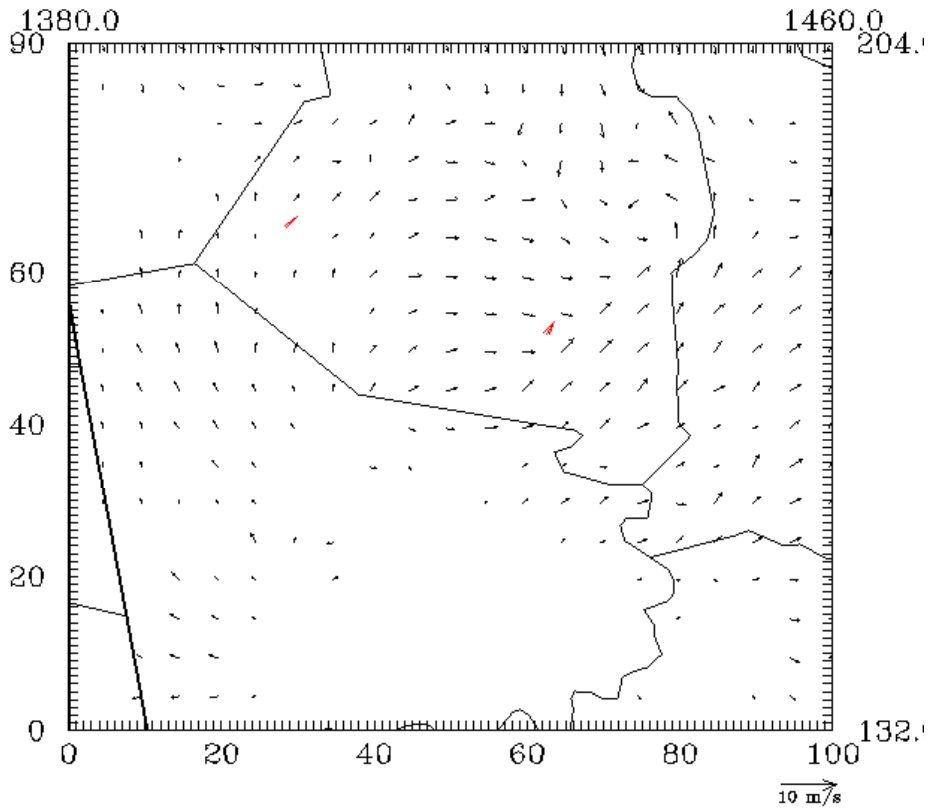




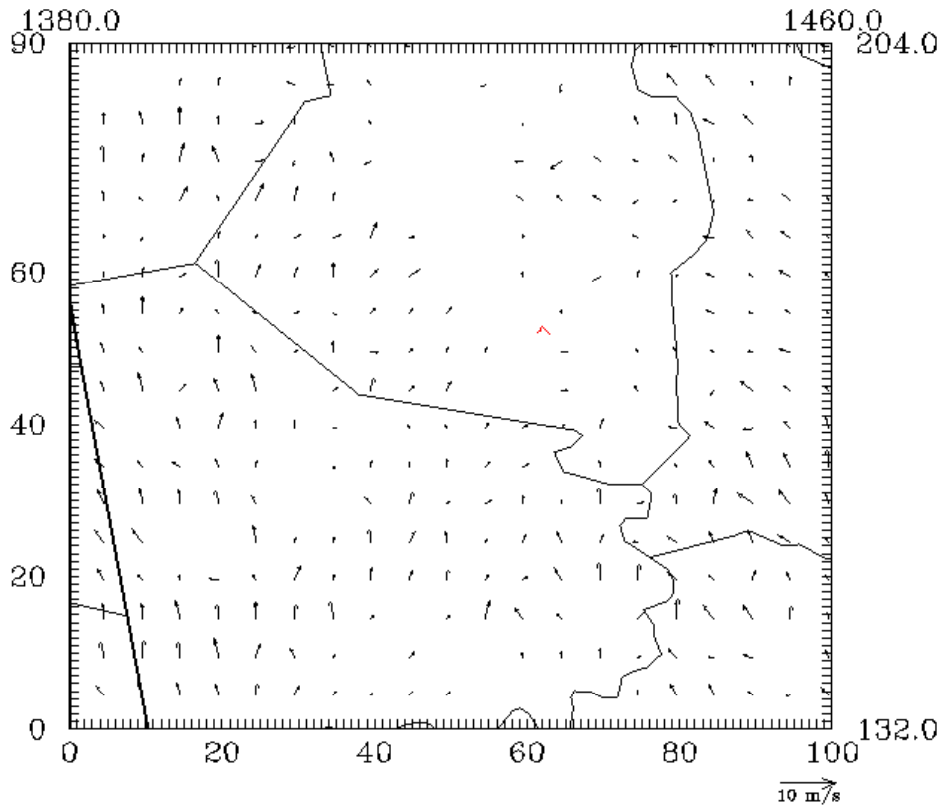
ALPINE GEOPHYSICS

ENVIRON

Winds
800 m July 4



Level 1 Hour 0
Date 7/ 4/07
VWND



Level 1 Hour 4
Date 7/ 4/07
VWND

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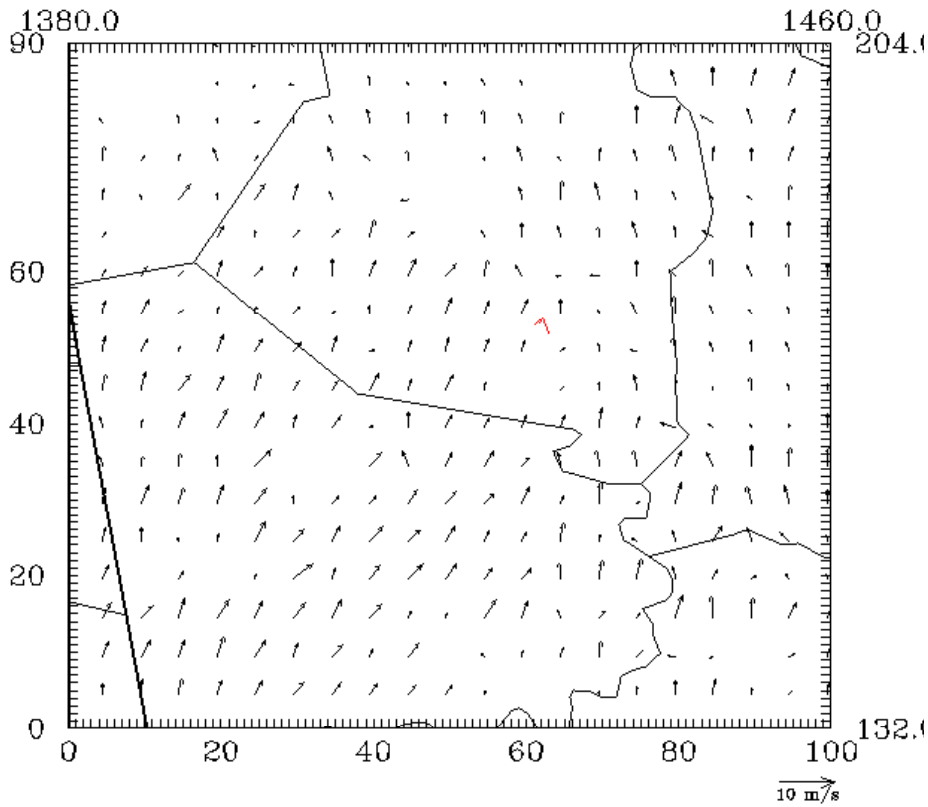
ENVIRON

Winds
800 m July 4



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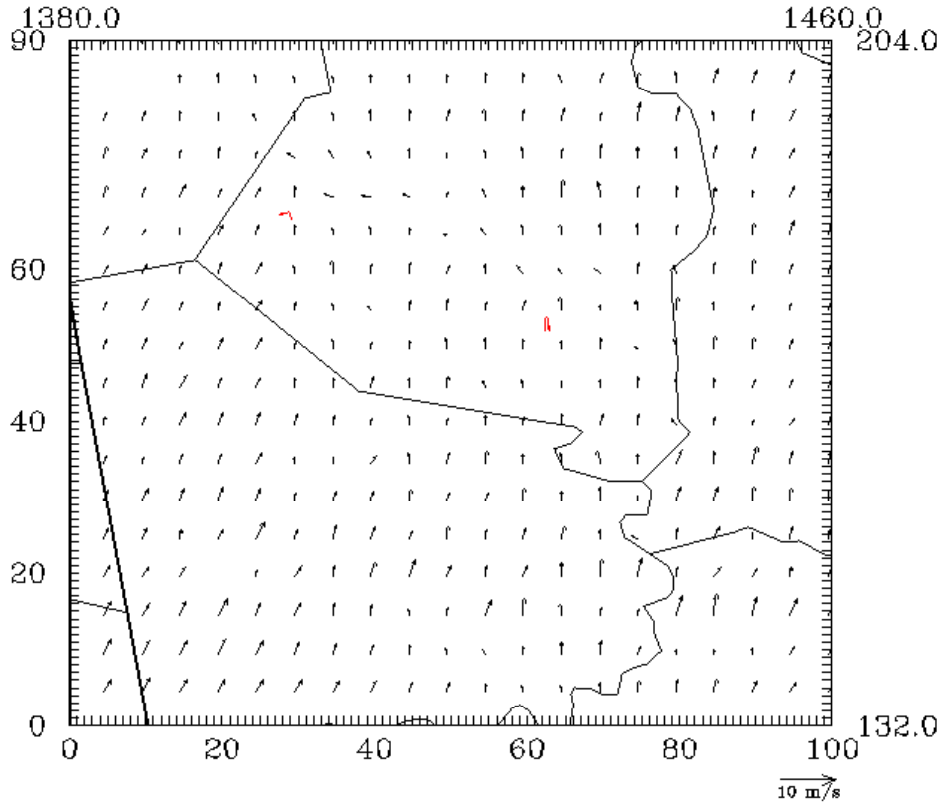

Level 1 Hour 12
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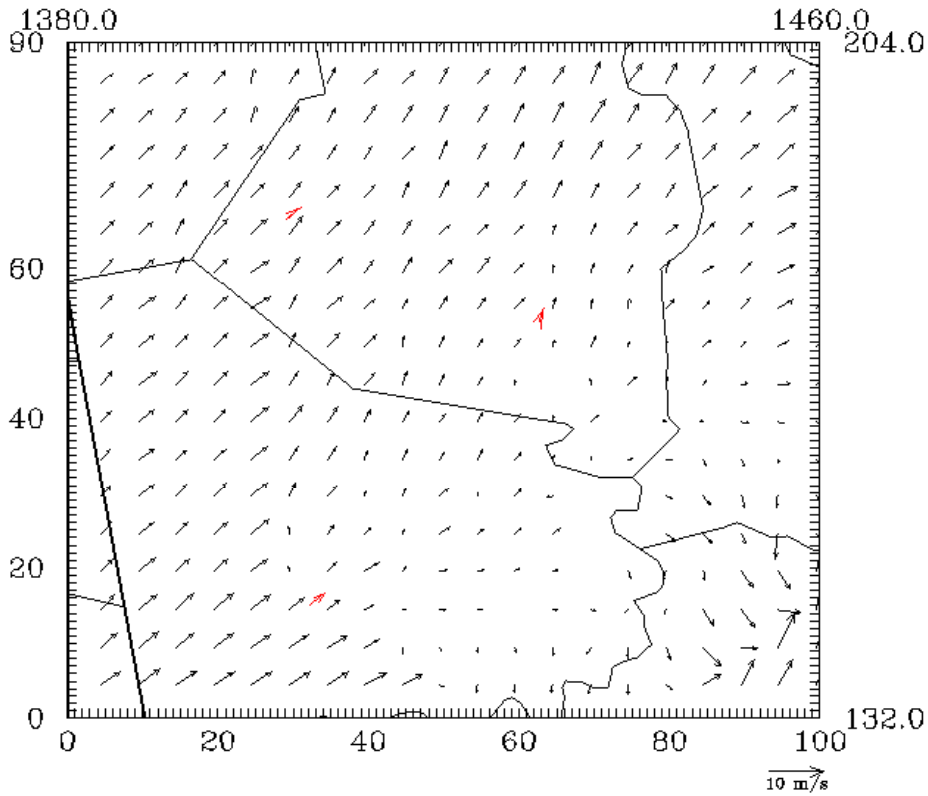
VWND

ALPINE GEOPHYSICS

ENVIRON

Winds
800 m July 4



Level 1 Hour 16
Date 7/ 4/07
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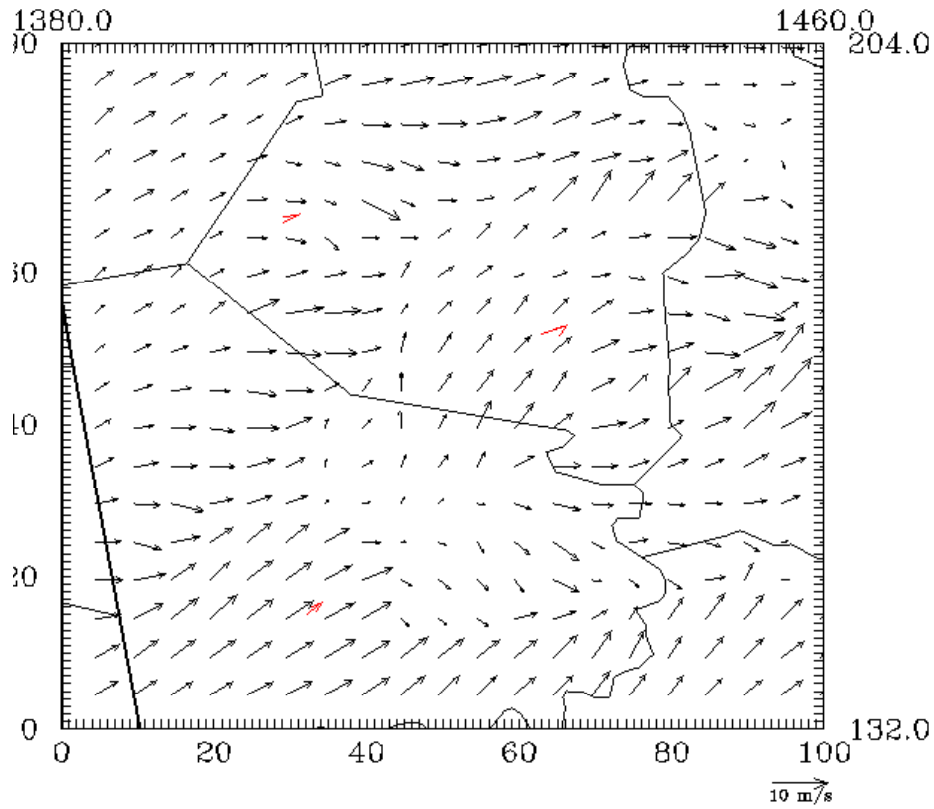


Level 1 Hour 20
Date 7/ 4/07
VWND

Qualitative Conclusions

- Precipitation
  - 36/12 km Precipitation Pretty Good
    - Captures both extent and magnitude of precip.
    - Somewhat overestimates in south
  - 4km Precipitation Acceptable
    - Tending to overestimate
  - 800 m Precipitation Concerning
    - Model greatly overestimating
    - Should consider flexi-nesting precipitation from coarser grid
- Winds
  - Wind vectors look reasonable

Overall Conclusions

- No concerns with use of 36/12/4
- Care must be taken with 800m
  - Consider using “flexi-nested” precipitation in CAMx
  - Should examine hour-to-hour wind performance for high PM episodes in PGM model.
    - Hourly wind vector plots are available

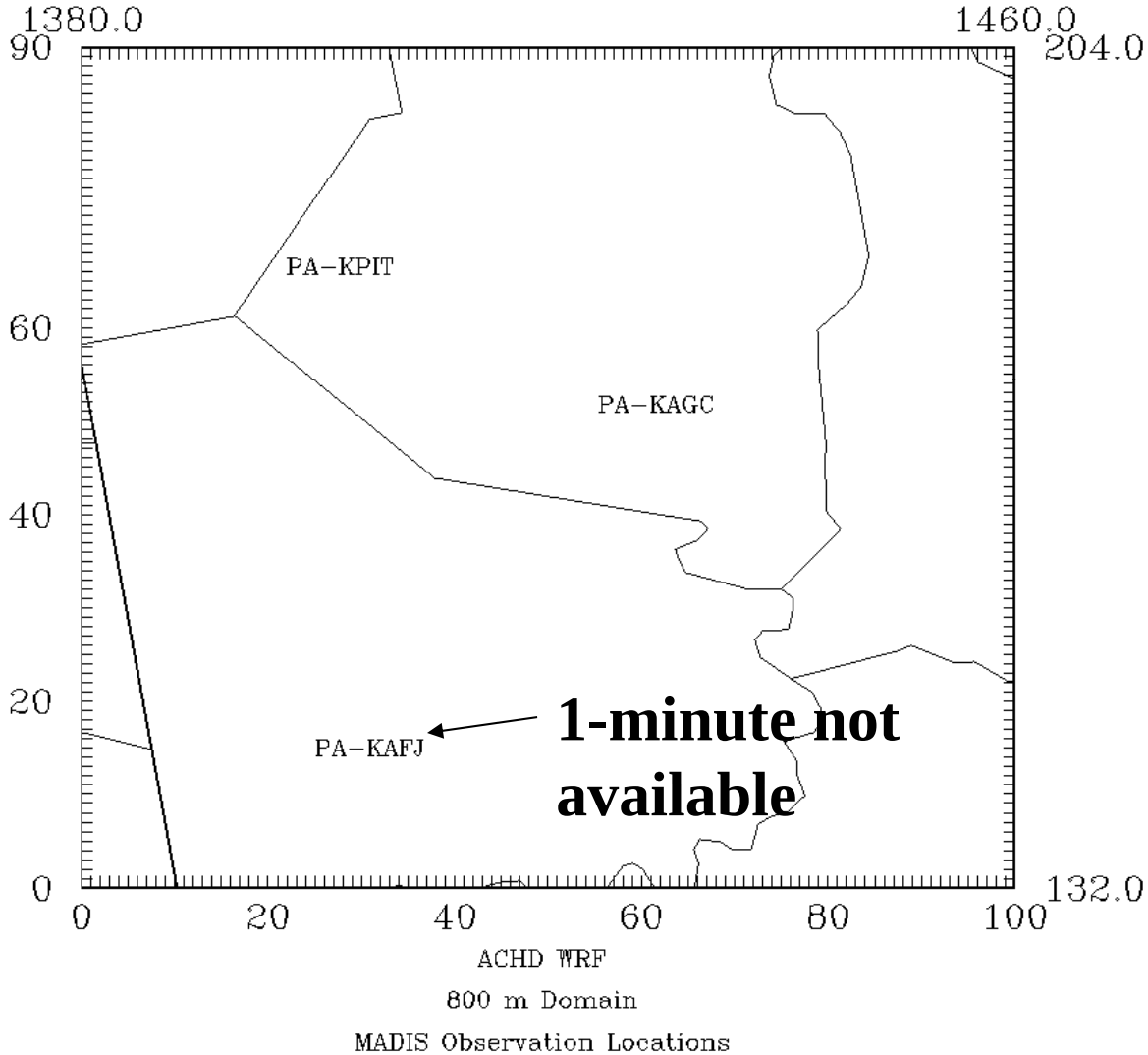
AERMINUTE Introduction

- **Issue with how Automated Surface Observing Stations (ASOS) handle low wind speed**
  - **ASOS reports winds less than 3 knots as 0**
    - **Leads to excessive number of calm winds**
- **AERMINUTE uses 1-minute ASOS data to calculate hourly average wind speed**

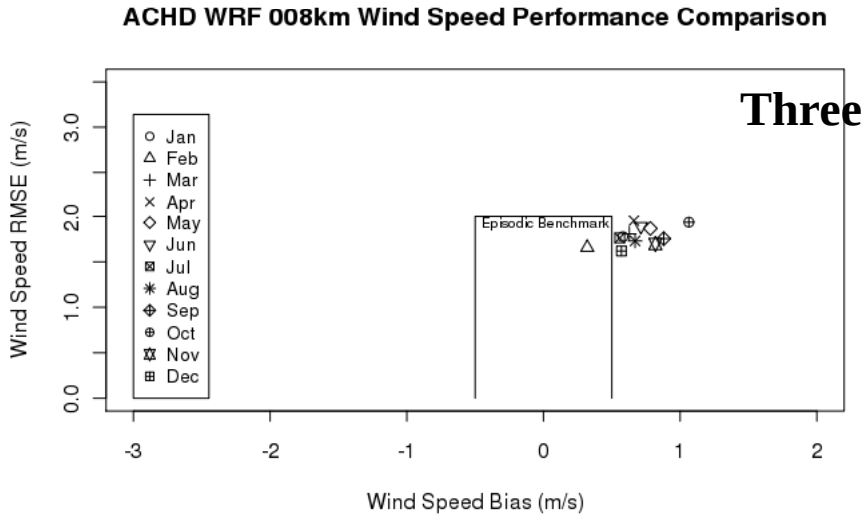
WRF Evaluation Experiment using AERMINUTE

- 800 meter WRF domain performance evaluation repeated using AERMINUTE processed observations.
- ASOS 1-min (NCDC DS-6405) was reformatted into METSTAT format by ENVIRON
  - Could only locate data for KPIT (Pittsburgh International) and KAGC (Allegheny County Airport)
  - KAFJ (Washington County Airport) not in archive, not an ASOS site

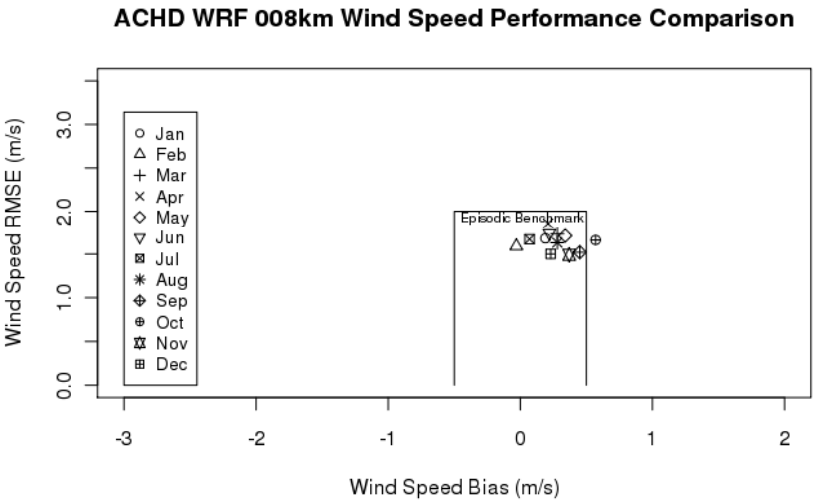
WRF Modeling Domains



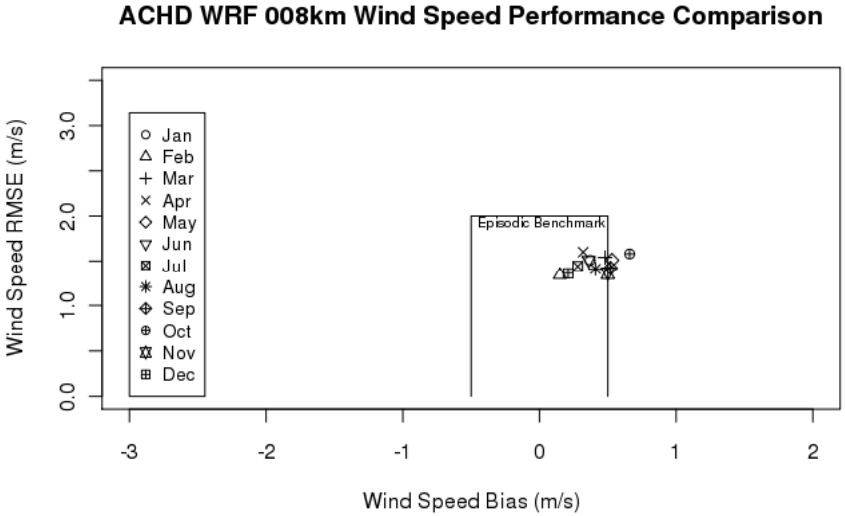
Wind Speed Comparison



Three Stations Hourly Data

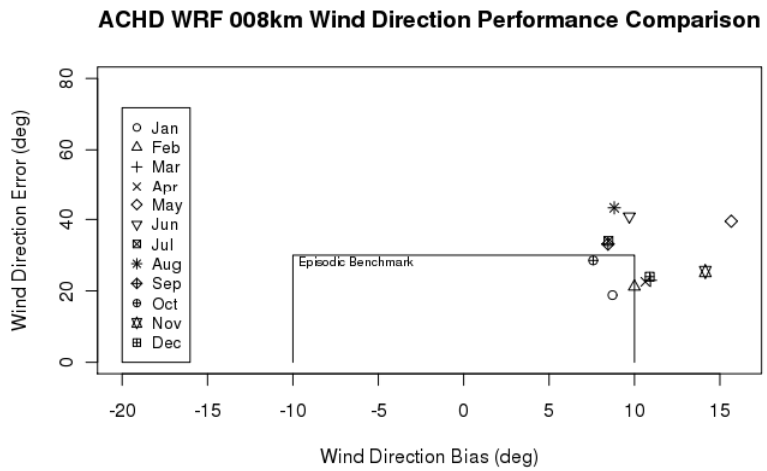


Hourly Data

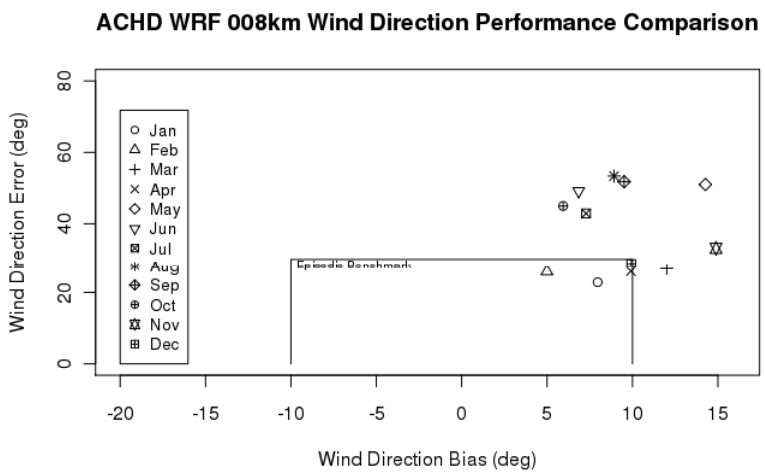


Two Stations AERMINUTE Data

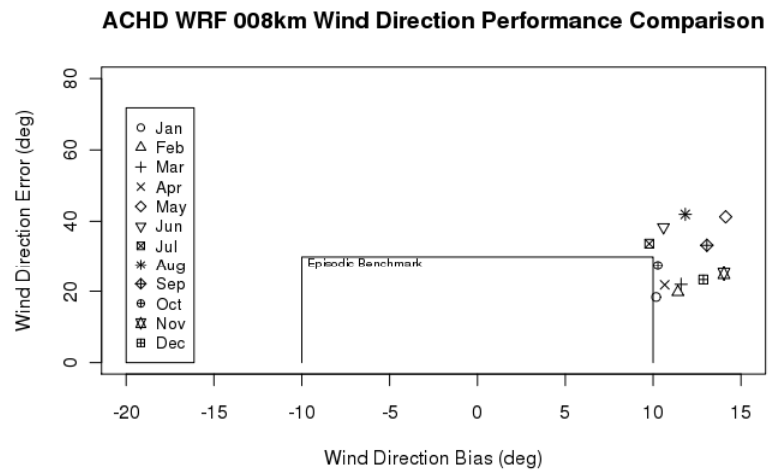
Wind Direction Comparison



Three Stations
Hourly Data



Two Stations
Hourly Data



Two Stations
AERMINUTE Data

AERMINUTE Conclusions

- Use of AERMINUTE had little impact on performance evaluation
- Primary reason for systematic wind overestimation in 800m grid was due to poorer performance at KAFJ (Washington County Airport)
- Interestingly, AERMINUTE data showed lower wind direction bias than hourly data