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Boulder, Colorado

Evaluation of fine-scale WRF modeling for winter ozone episodes in SW Wyoming

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WRF for Winter-time Ozone Episodes

Outline:

- Big Picture
- WRF options
- WRF Performance
- Summary/Discussion

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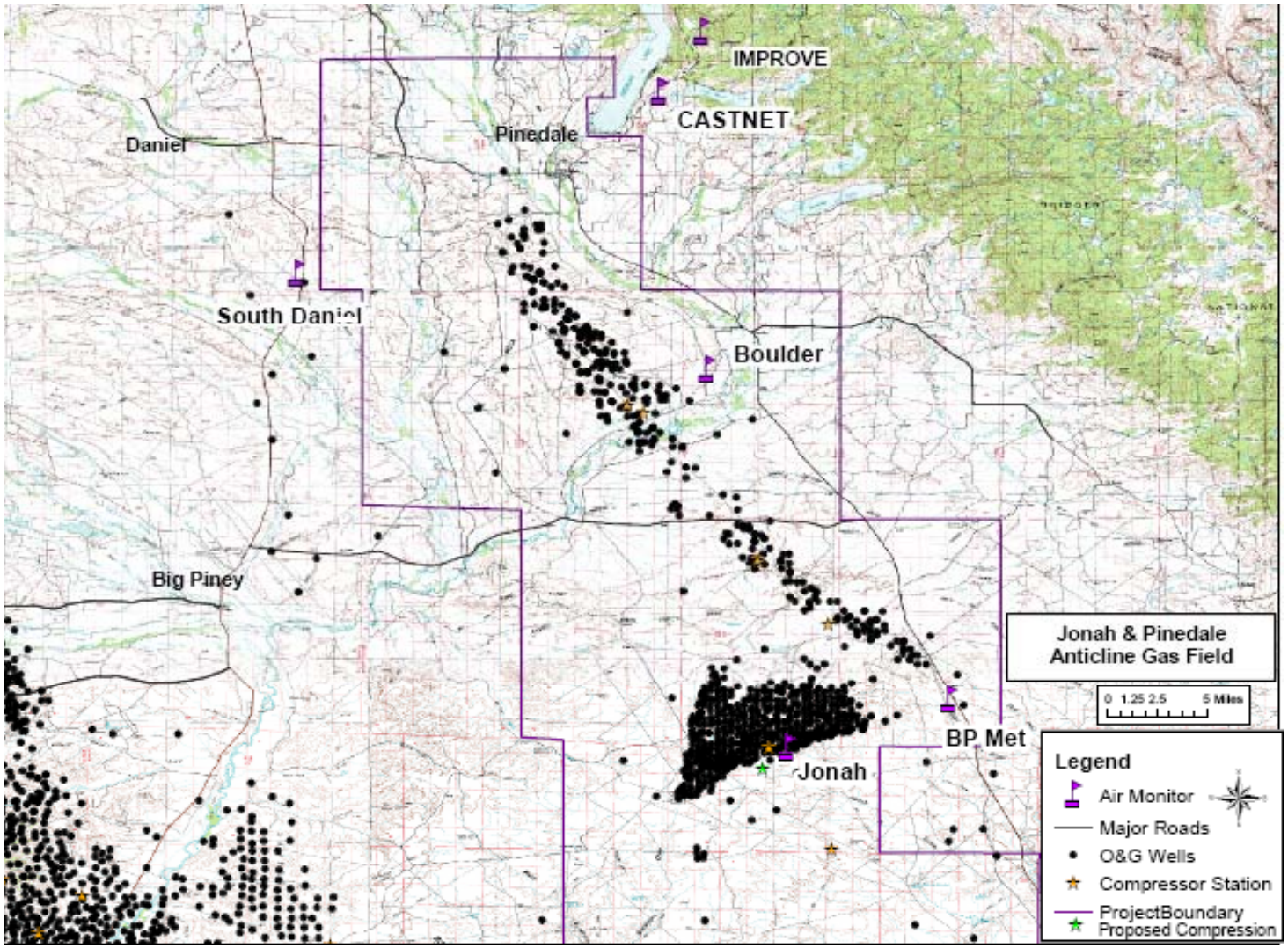
Big Picture

- High ozone concentrations found in Upper Green River Basin (UGRB) in late Winter
  - 14 days in 2008 with 8-hr O_3 > 75 ppb
  - February and March
    - Snow cover doubles the solar effect
  - Clear skies, high pressure, strong inversion, very stable
  - Many Oil and Gas wells in the area

Local Anthropogenic Sources 2005



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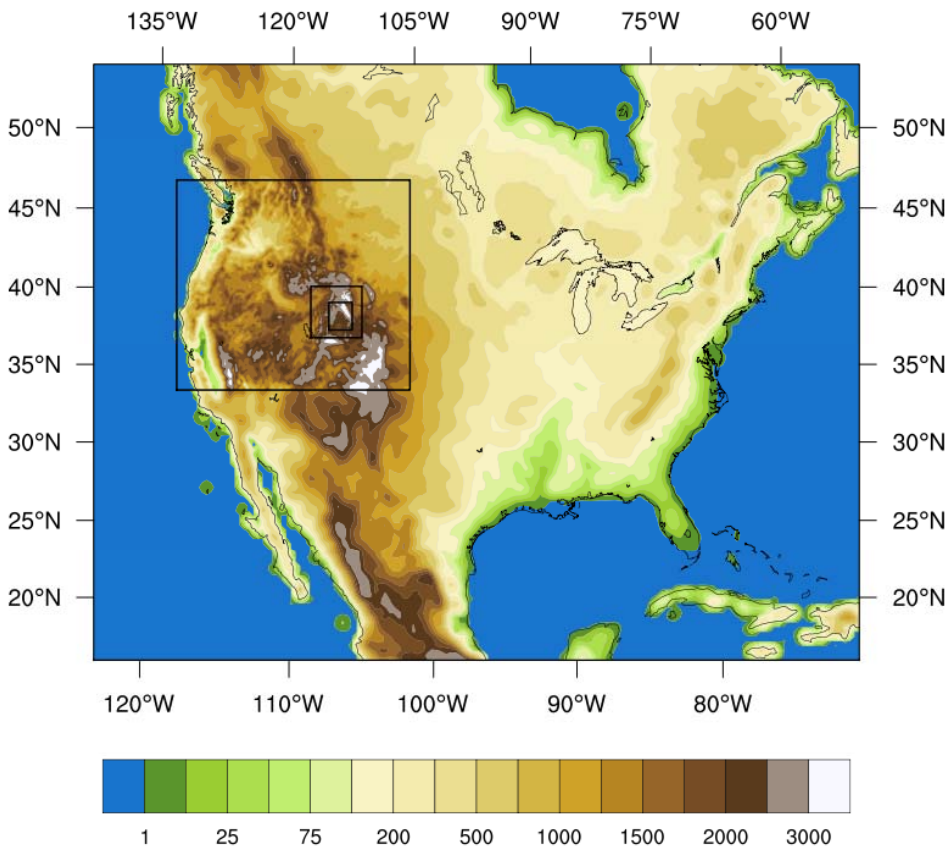
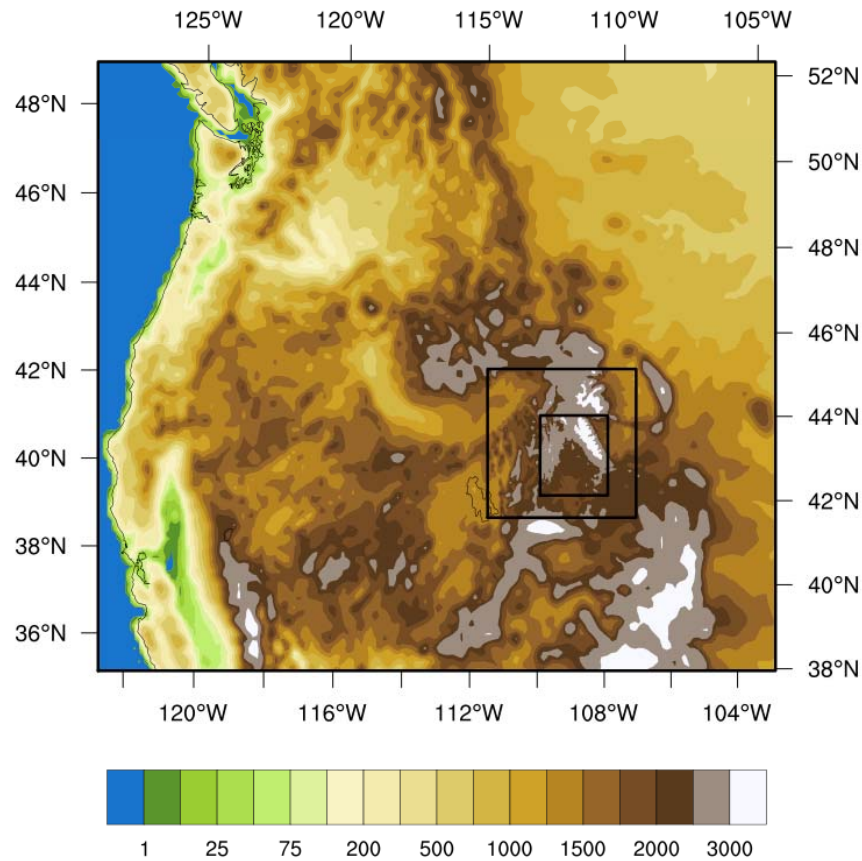
WRF Setup

- WRF v3.3
- 1 Feb to 31 Mar 2008
  - 5-day chunks with 12-hour spin-up
- LCC "RPO" projection: 36, 12, 4, 1.33 km
  - One-way feedback
- 36 vertical levels
- NAM 12km 6-hourly BC/IC
- NCEP RTG 0.083-degree SSTs
- MADIS and local UGRB OBS data

WRF Domain





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WRF Levels

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

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WRF Physics

- Performed 12 sensitivity runs
- MYJ+NOAH best
  - Best balance of profiles and inversion strength
- YSU+NOAH second-best
  - Slightly sharper and more accurate inversions
  - Frequently produced spurious fog – too humid
- Final Physics:
  - 3-class Microphysics
  - KF Cu on 36 and 12km
  - MYJ PBL, NOAH LSM
  - RRTMG long- and short-wave

Nudging

- 3D Analysis: 36, 12 and 4km (no T,q in PBL)
- 2D Surface: 4km
- OBS: 4 and 1.33km (winds only)

Nudging	Domains Applied	Nudging Strengths (1/s)		
		Wind	Temperature (no PBL)	Humidity (no PBL)
3-D Analysis	36 12 4	5×10^{-4} 3×10^{-4} 3×10^{-4}	5×10^{-4} 3×10^{-4} 3×10^{-4}	5×10^{-4} 3×10^{-4} 3×10^{-4}
2-D Surface	4	3×10^{-4}	3×10^{-4}	3×10^{-4}
Observational	4 1.33	1×10^{-3} 1×10^{-3}	NONE NONE	NONE NONE

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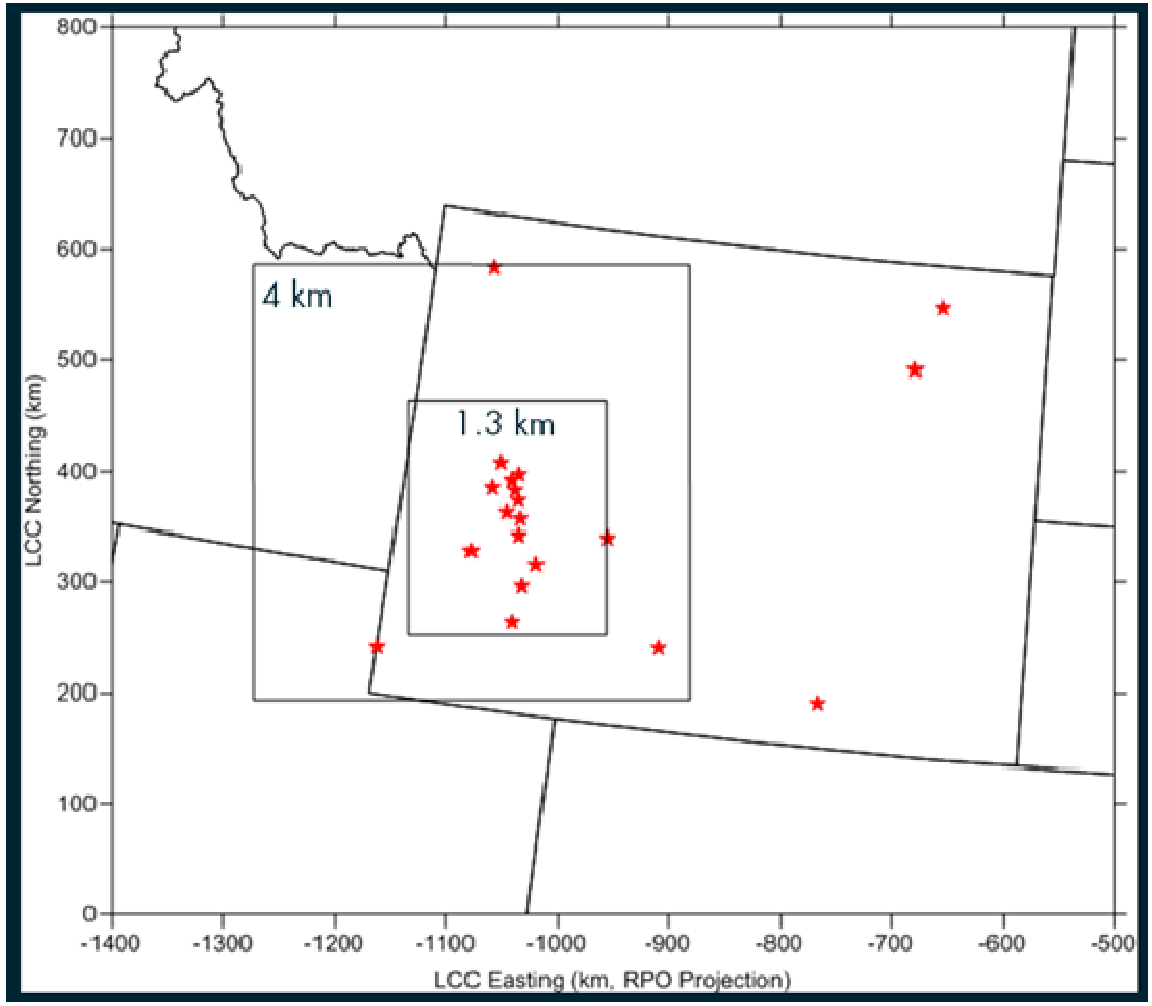
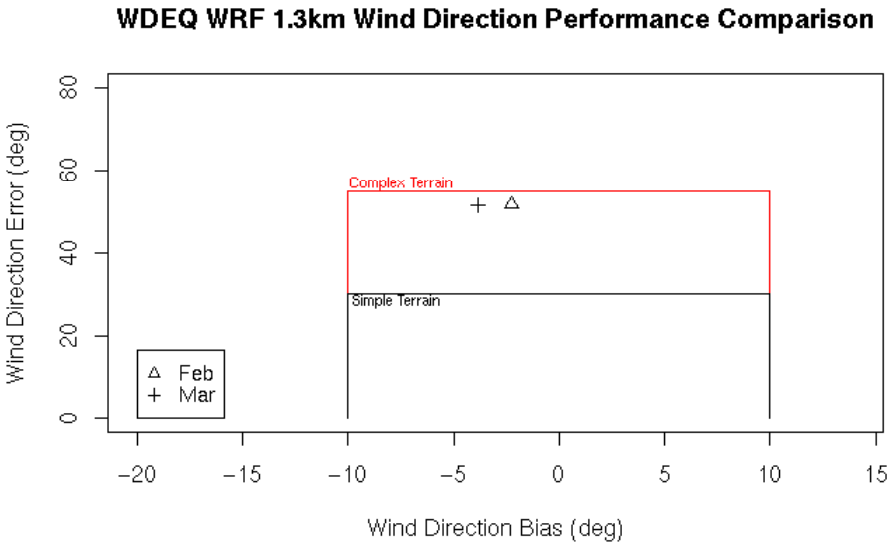
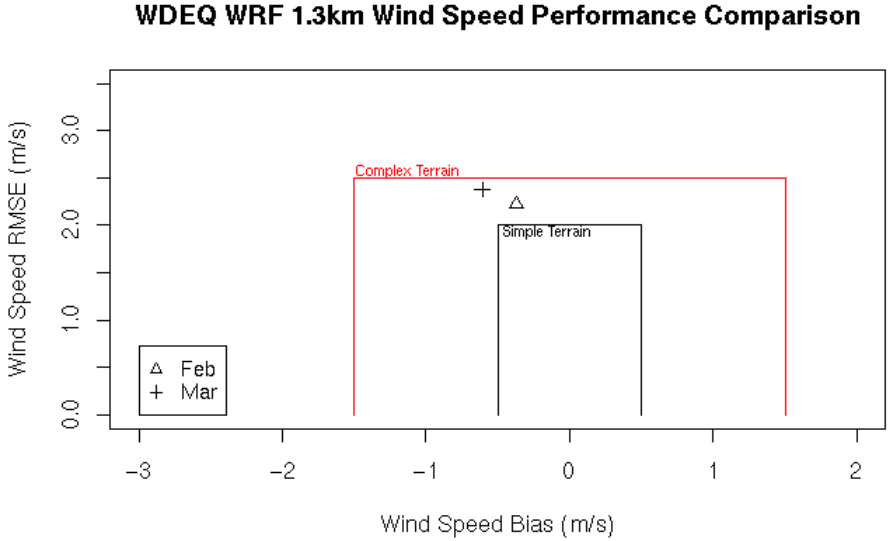
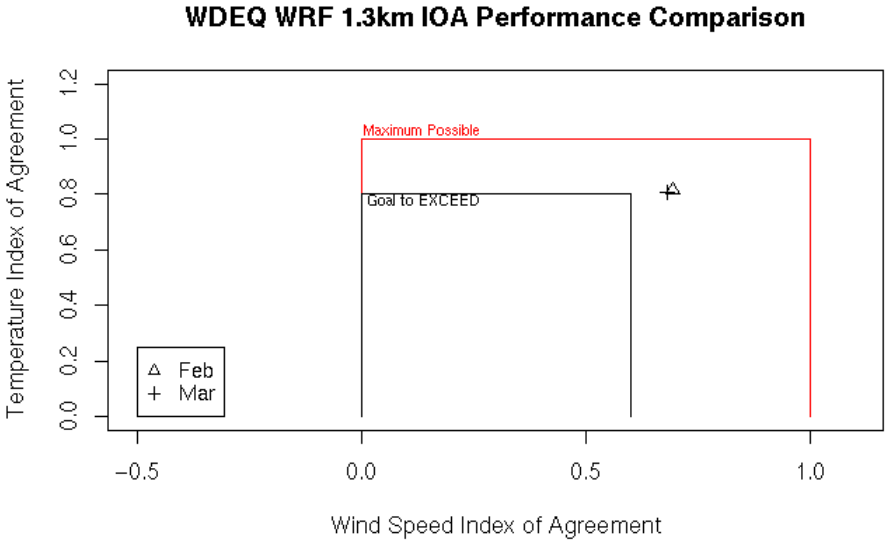
WDEQ Observation Sites

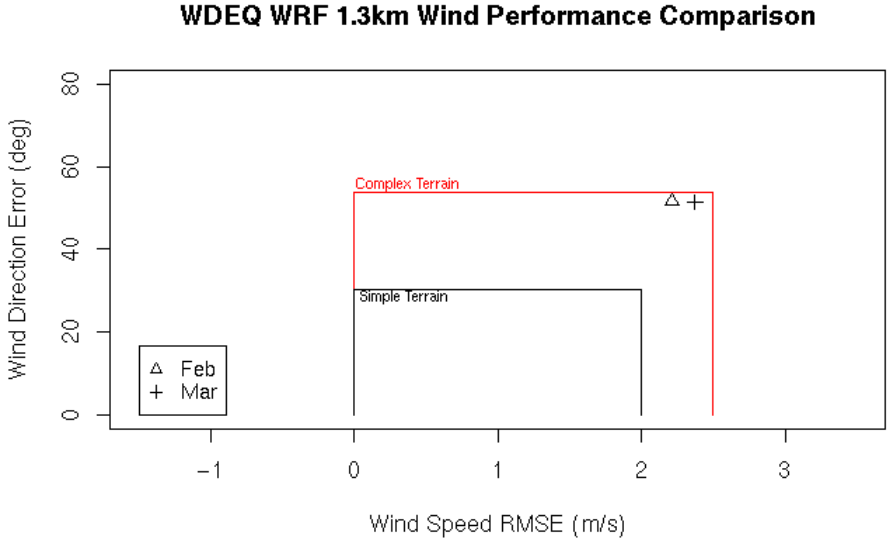


1.33km Wind Statistics









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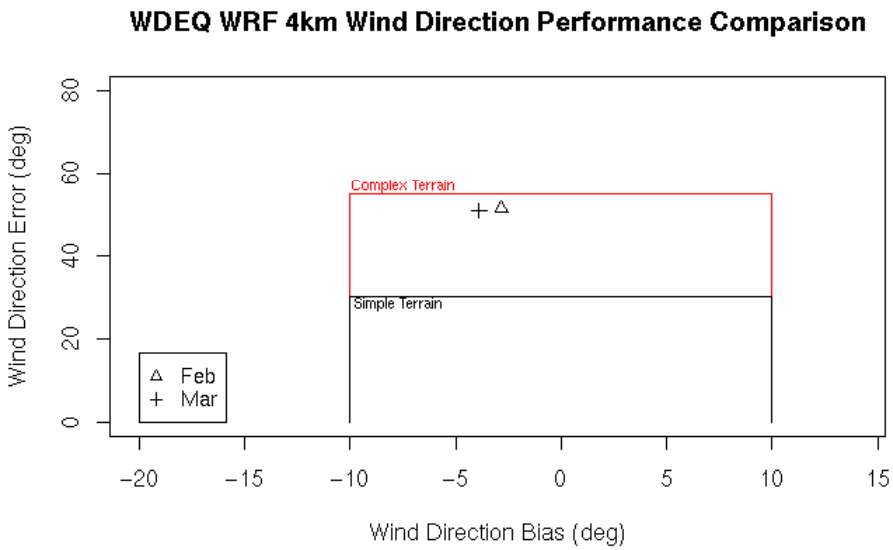
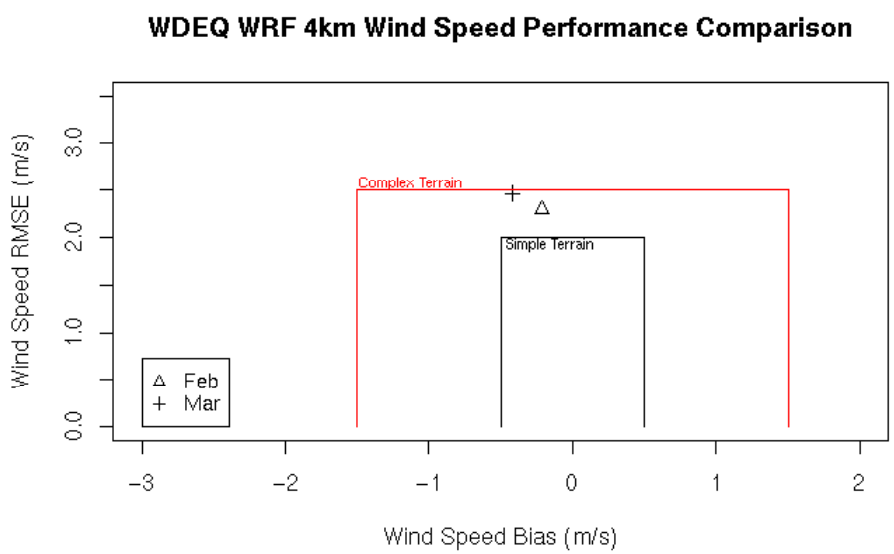
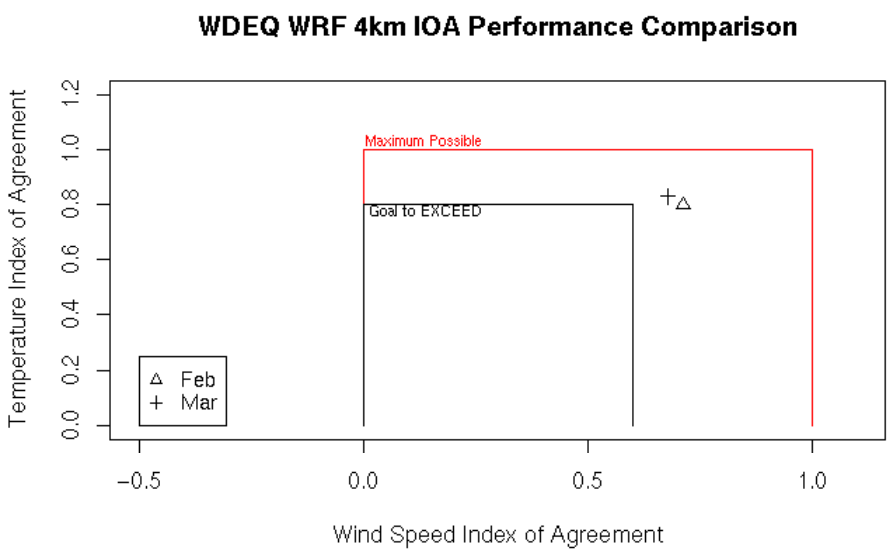
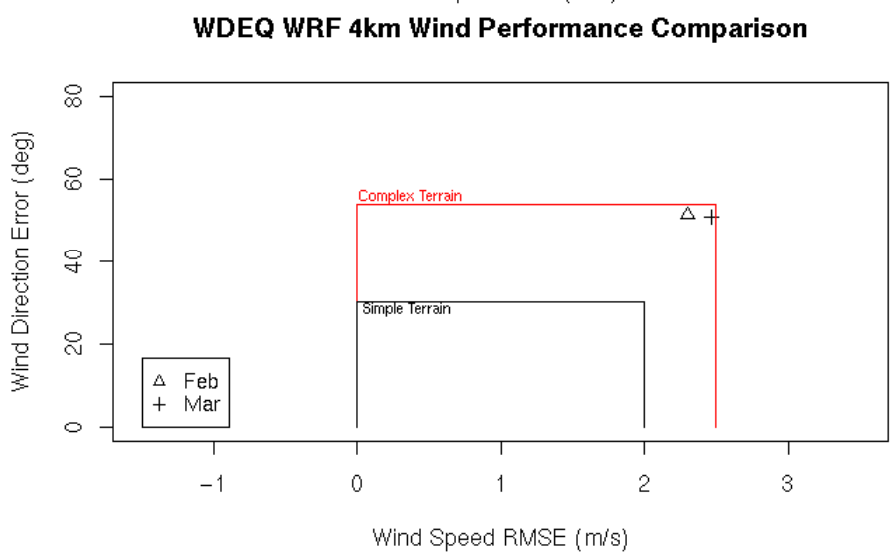
4km Wind Statistics









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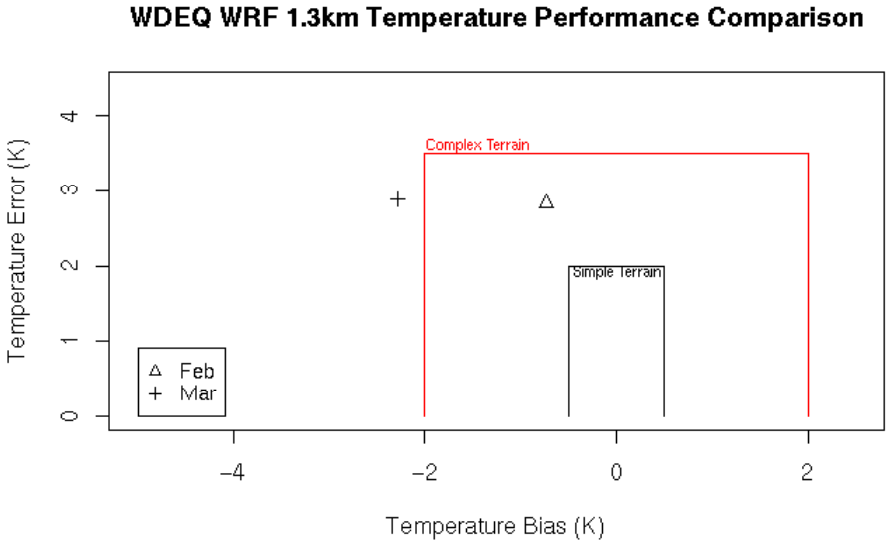
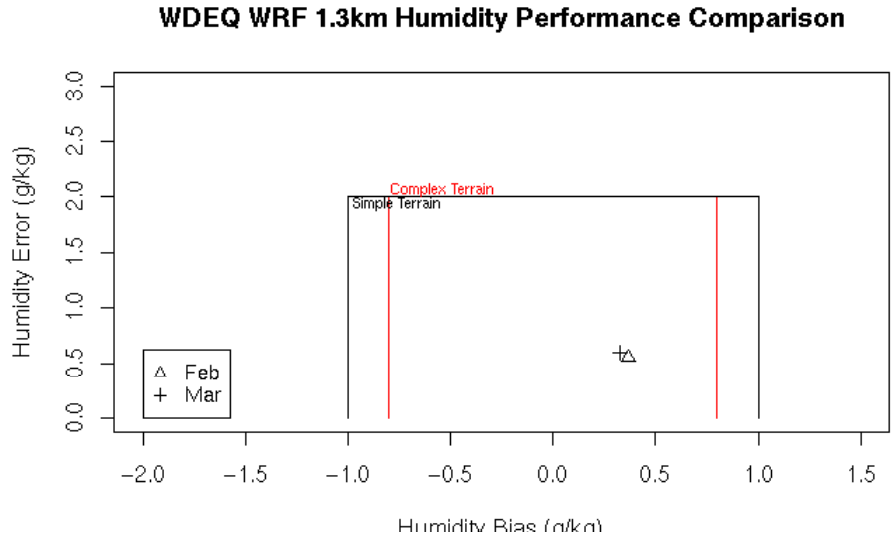
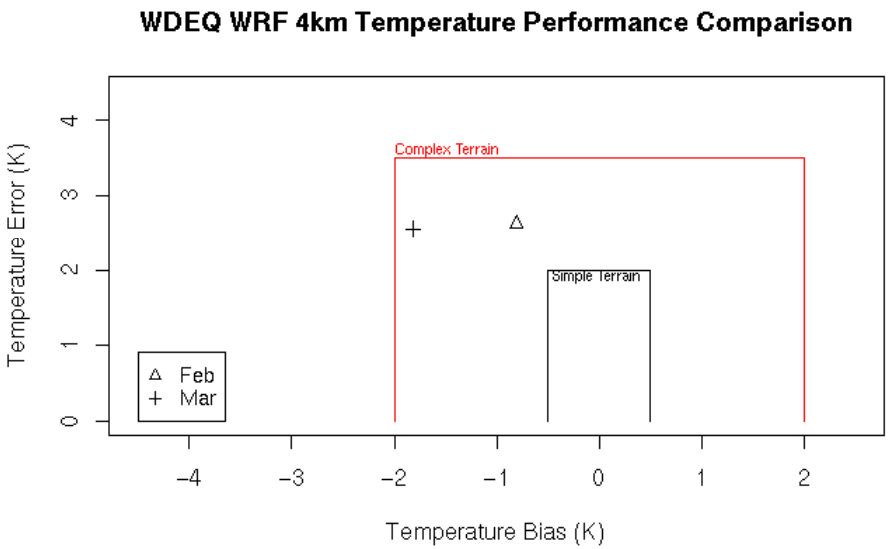
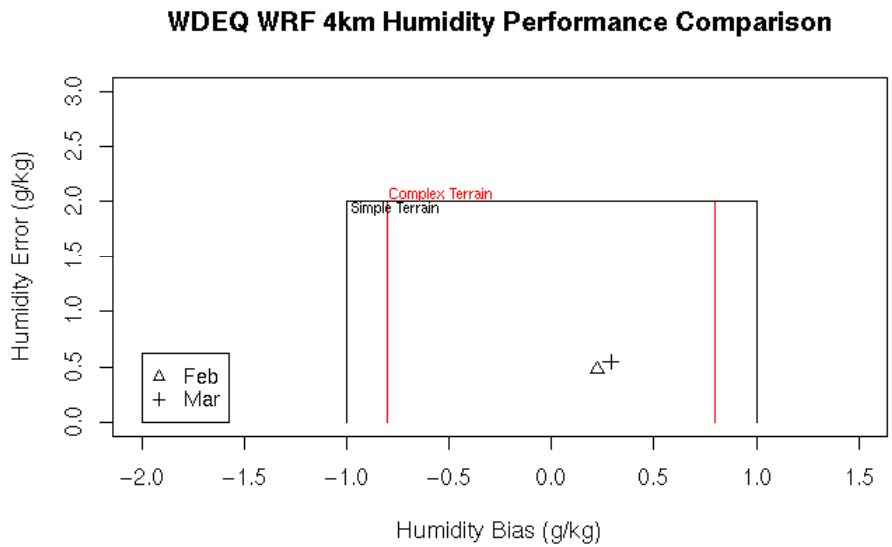
Temperature and Humidity Statistics

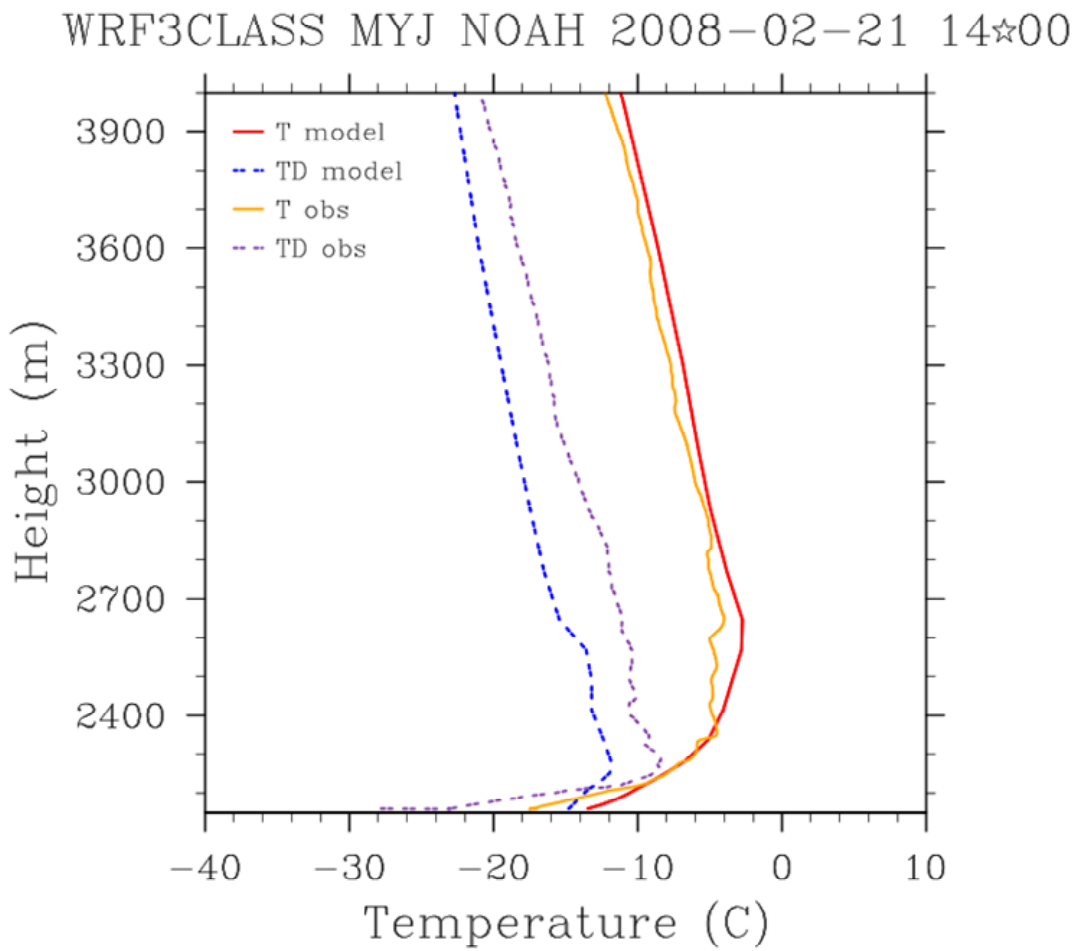




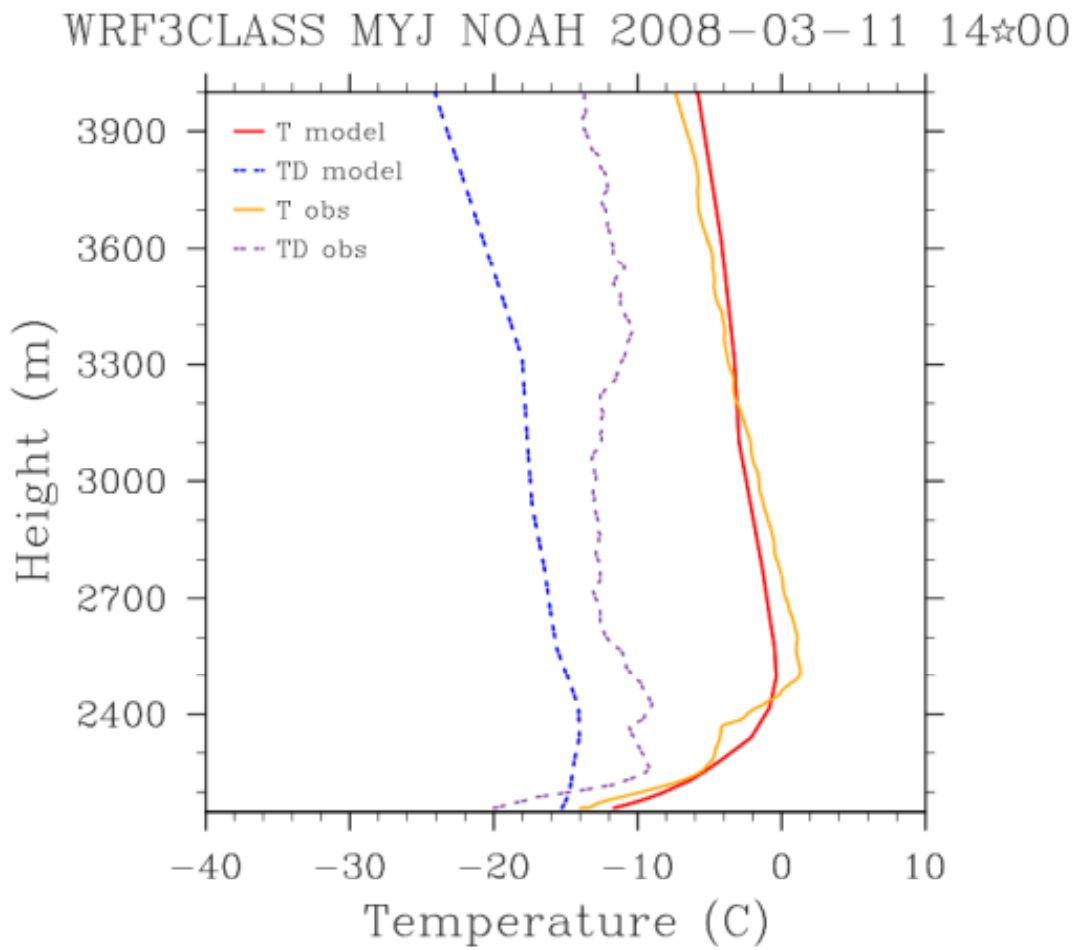




Profile #1 (max 8hr O_3 =122 μg/m³)

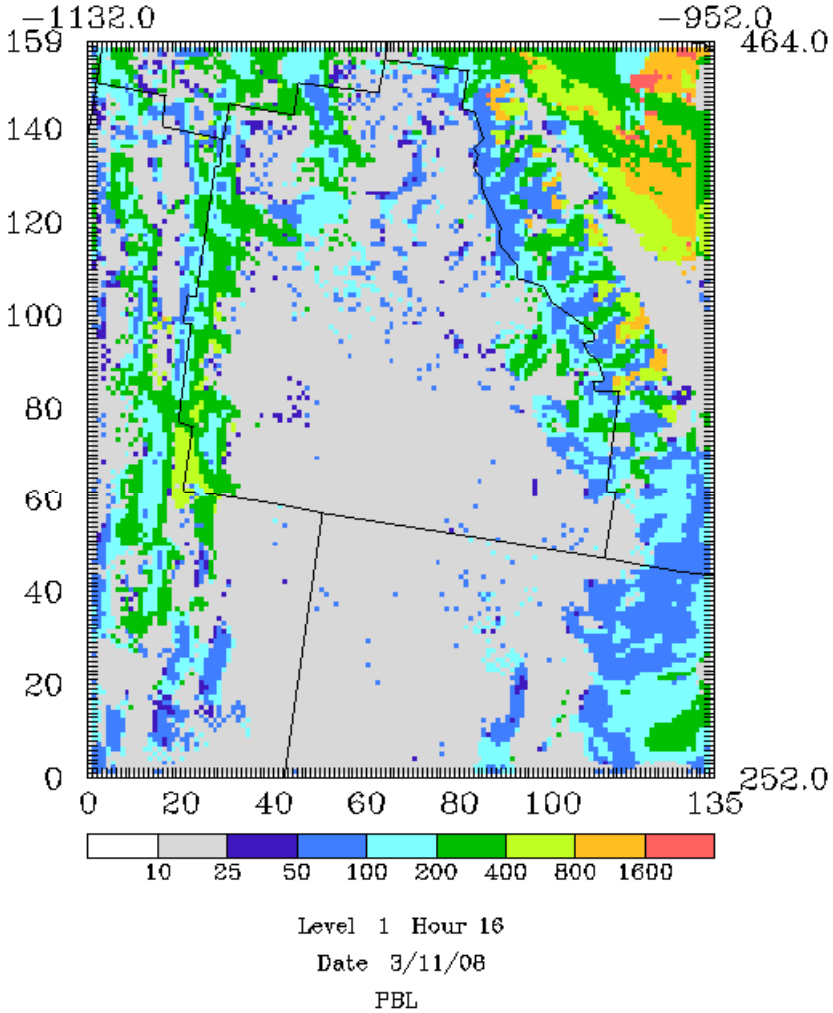


Profile #2 (max 8hr O_3 =102 μg/m³)

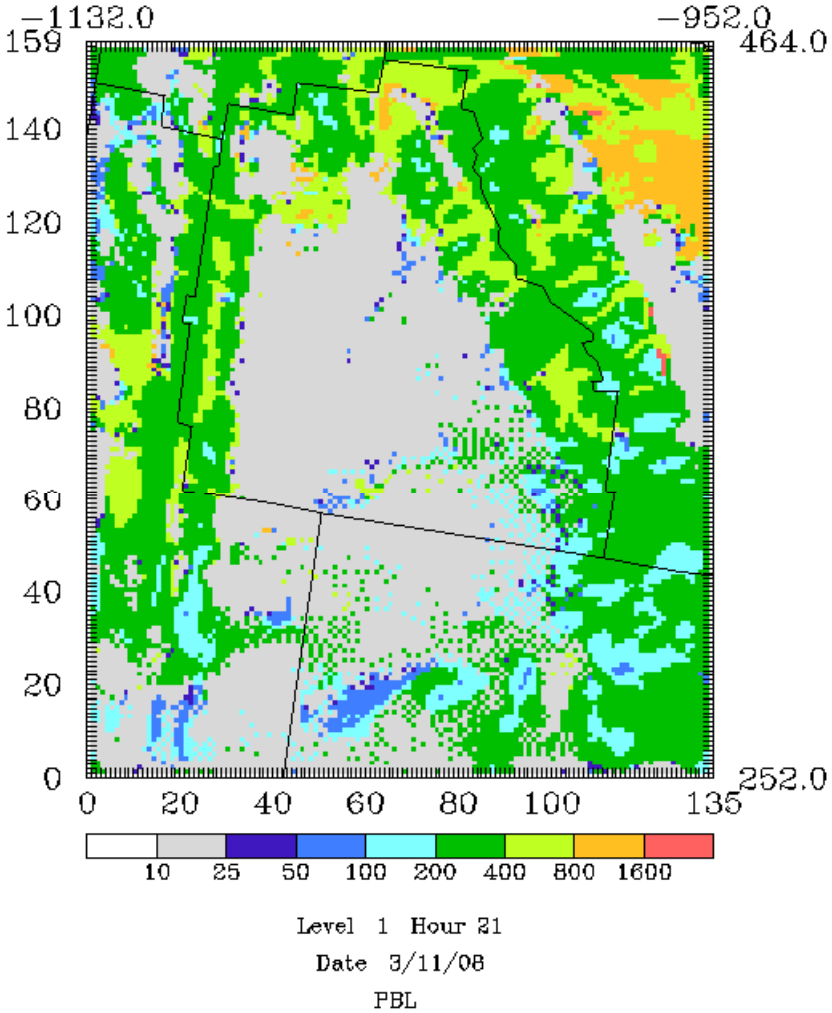


PBL Heights

9:00 AM MST



2:00 PM MST



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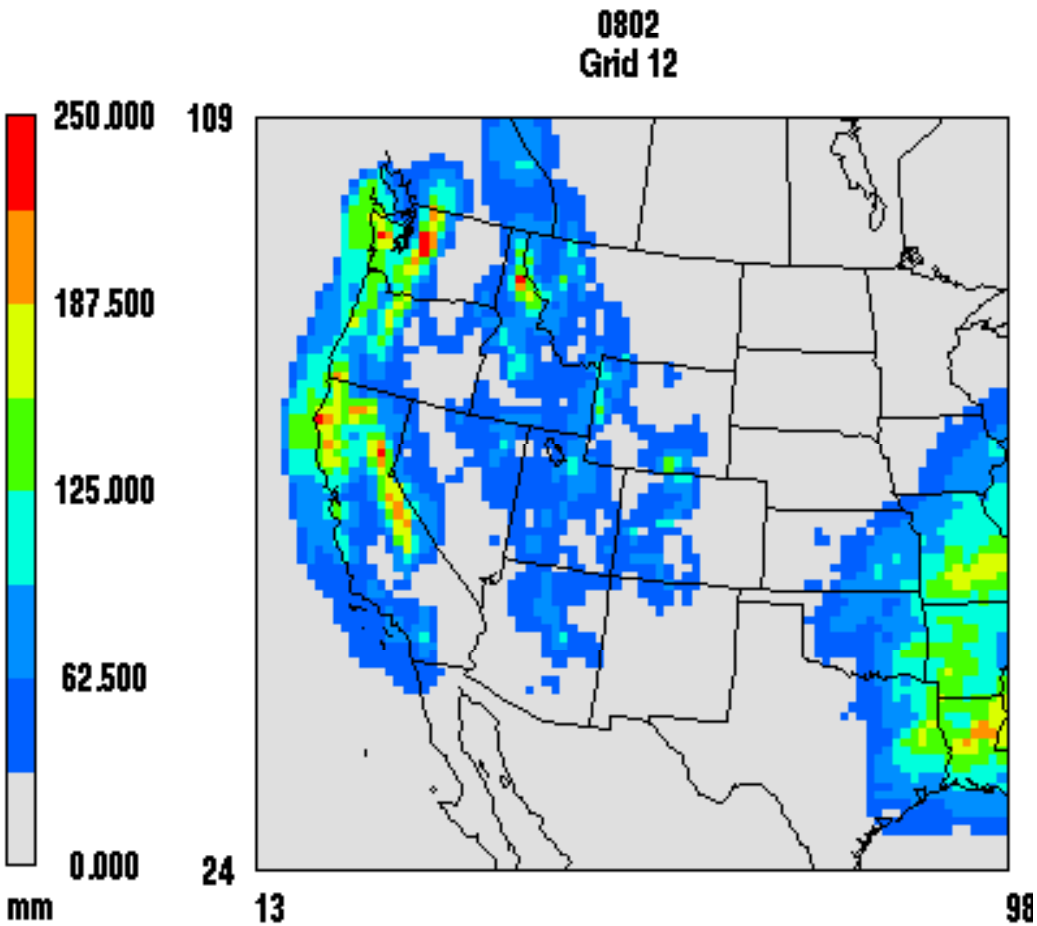
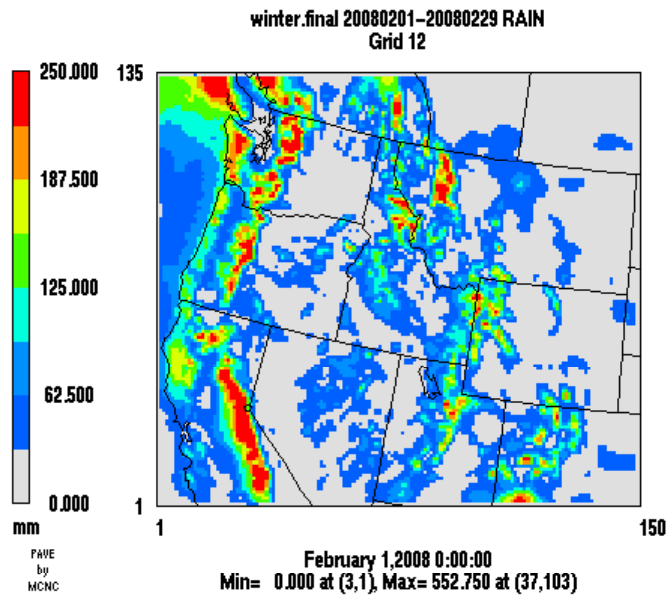
February Precipitation

CPC Precip



WRF Precip



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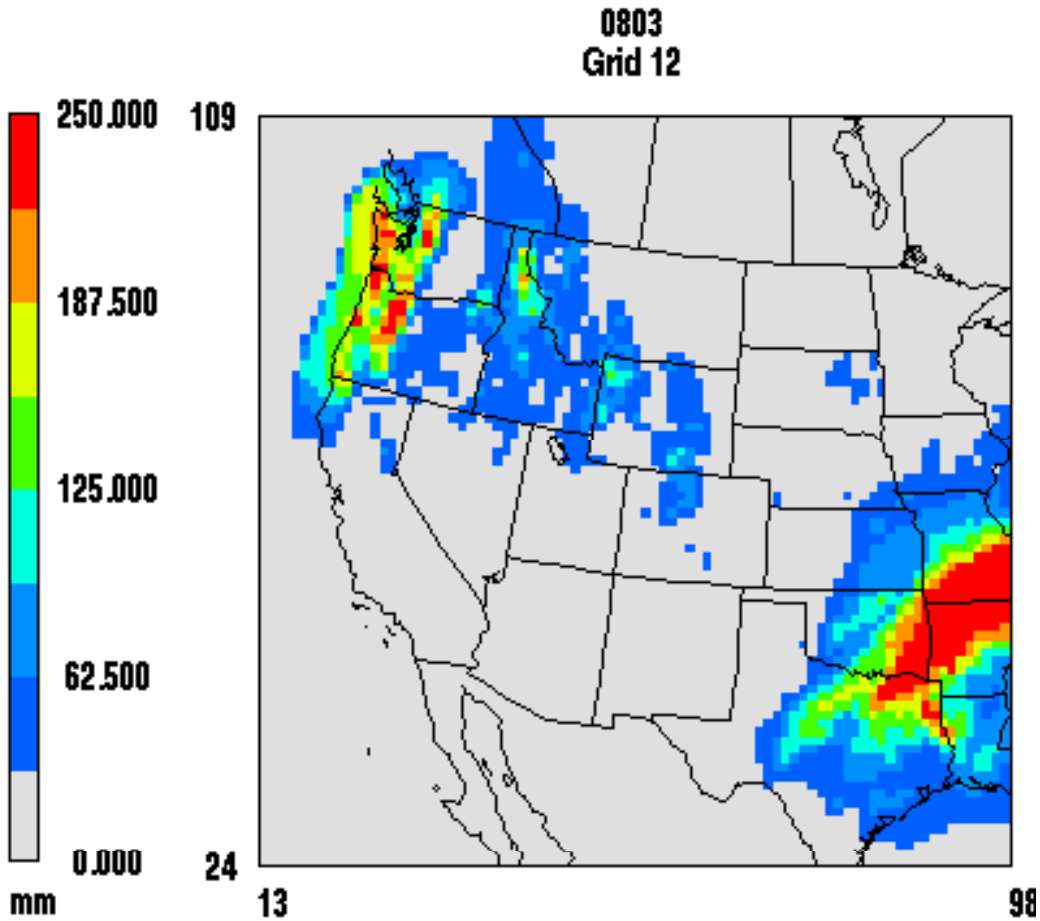
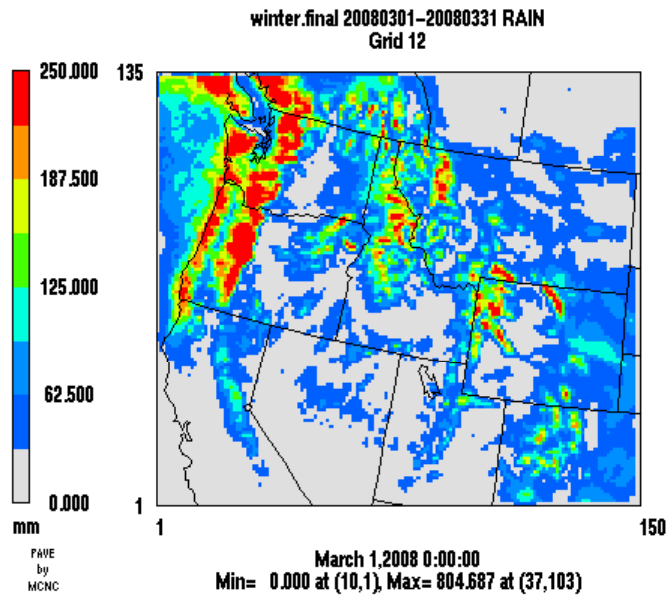
March Precipitation

CPC Precip



WRF Precip



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General “feelings” about these runs

- OBS nudging helped the humidity but hurt the temperature and winds (c.f. Gaudet and Stauffer).
- Night-time negative temperature bias in March due to NAM-12 having too much snow (compared to SNODAS data).
- Humidity in NAM-12 seems too high – gave too much precipitation.
- WRF’s PBL heights “snap” to mid-layers – discretized.
  - Not so useful for dispersion modelers.

Discussion?

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