MM5 Sensitivity Modeling, Mainly in Support of VISTAS (Visibility Improvement State and Tribal Association of the Southeast)

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c/o

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Status at last ad hoc meeting . . .

- px-acm configuration
  - Initial VISTAS setup
    - P-X LSM
    - ACM PBL
    - RRTM radiation
    - Reisner 1 (mixed phase) microphysics
    - KF2 clouds
  - Based on prior RPO MM5 work
- Winter episode too cold
  - Better results if interppx not used
  - px_acm2 became new basecase

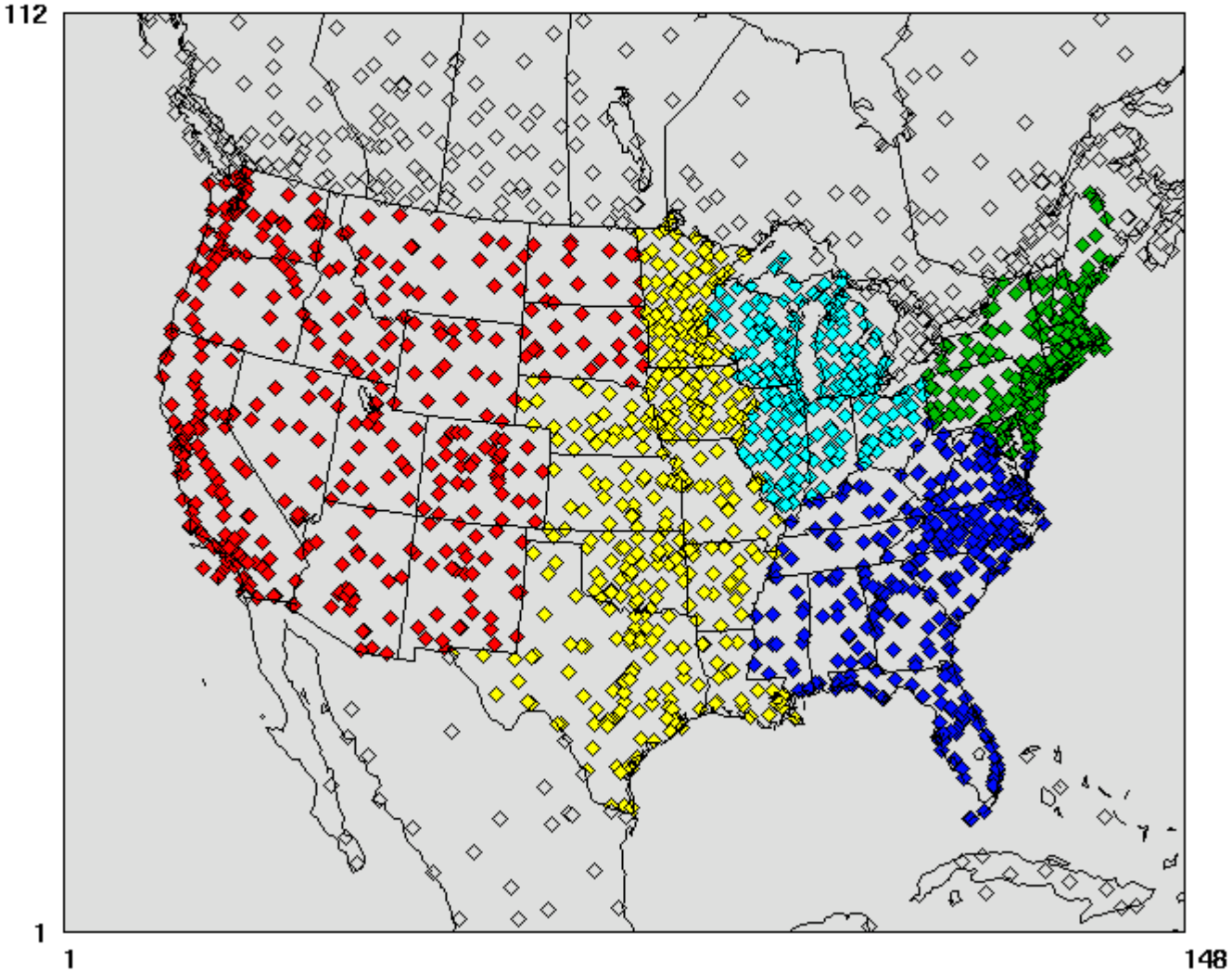
Since last ad hoc meeting . . .

- **4 main sensitivities**
  - px_acm(2)
  - noah_mrf
  - multi_blkdr
  - noah_eta-my

- **3 episodes**
  - **Episode 1: Jan 2-20, 2002**
    - 00Z Dec 26, 2001 – 12Z Jan 21, 2002
  - **Episode 2: July 13-27, 2001**
    - 00Z Jul 6 – 12Z Jul 28, 2001
  - **Episode 3: July 13-21, 1999**
    - 00Z Jul 9 – 12Z Jul 22, 1999

Evaluation Sites by RPO

(VISTAS: Dk blue; MANE-VU: Green; MIDWEST: Lt blue; CENRAP: Yellow; WRAP: Red)



4-panel plots

Available for all RPO regions:

- Temp (max, min, avg)
- Mixing Ratio (avg, 18Z-21Z avg, 07Z-10Z avg)
- PBL (18Z-21Z avg, 07Z-10Z avg)
- Wind Speed (18Z-21Z avg, 07Z-10Z avg)
- Relative Humidity (18Z-21Z avg, 07Z-10Z avg)
- Cloud Fraction (18Z-21Z avg, 07Z-10Z avg)
- Pcp (18Z-21Z avg, avg)

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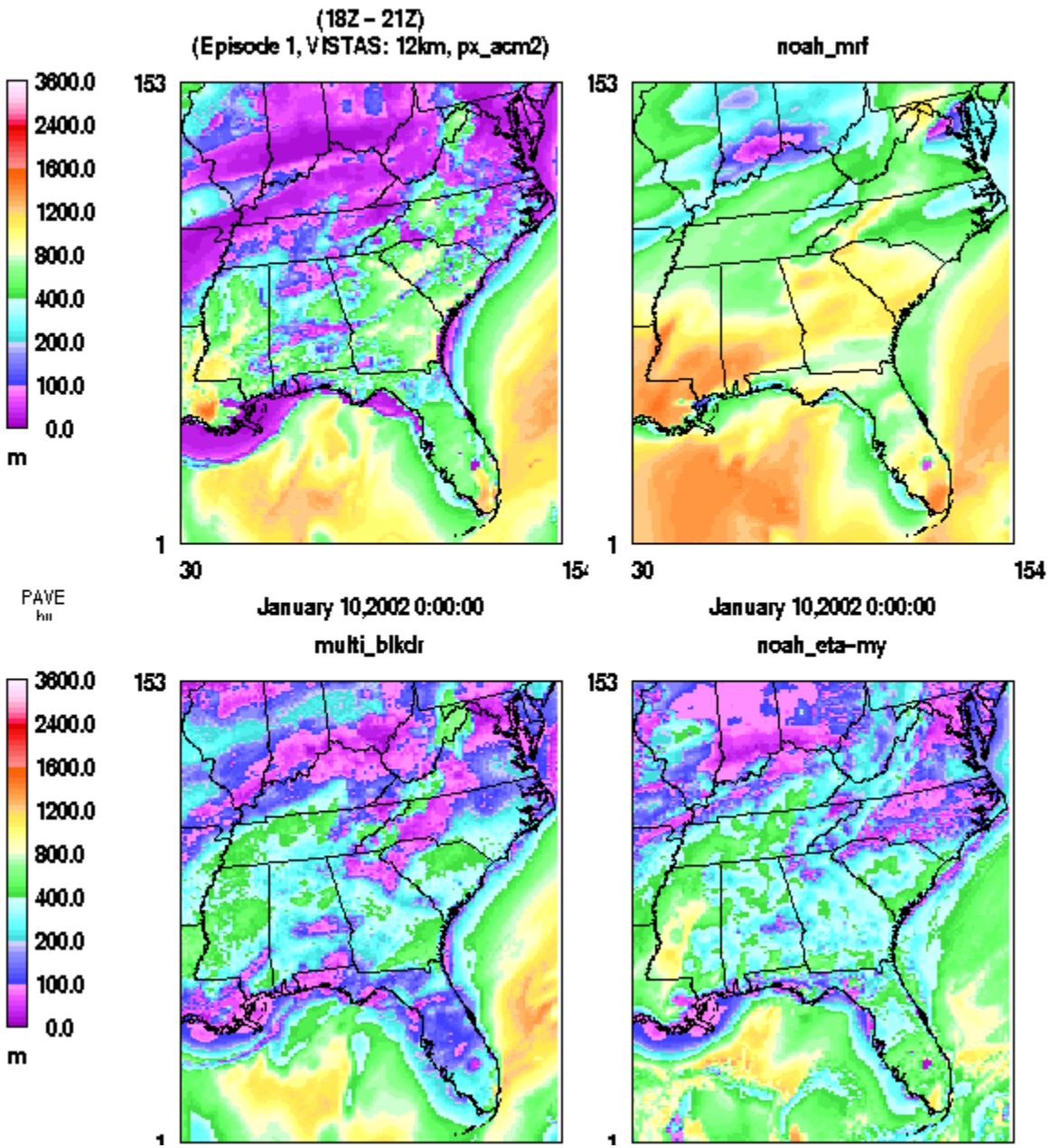
Daytime PBL average



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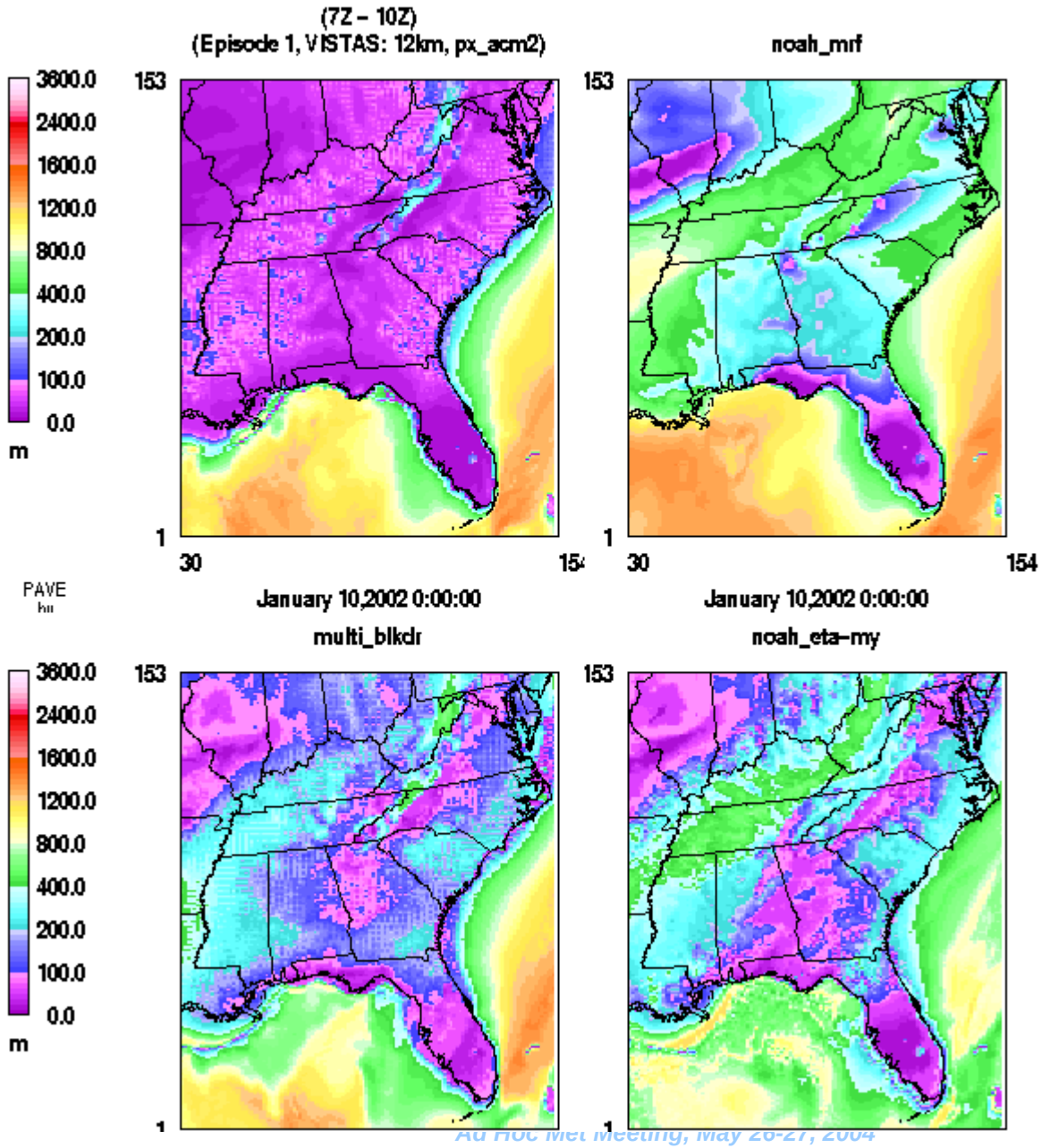
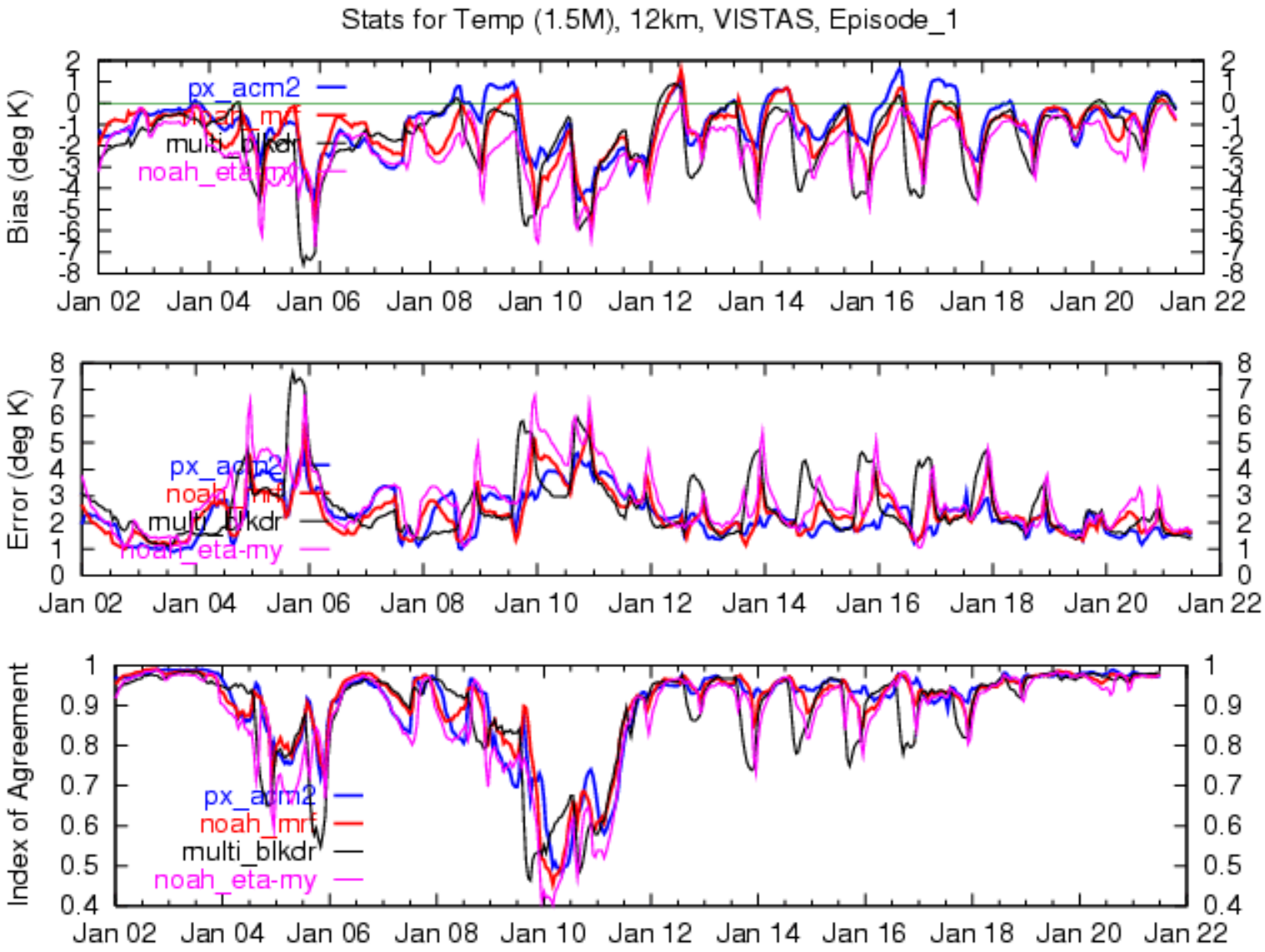
BAMS

Nighttime PBL average




Stats for Temp (1.5M), 12km, VISTAS, Episode_1
Bias (deg K)
px_acm2
noah_mrf
multi_blkdr
noah_eta-my
Error (deg K)
px_acm2
noah_mrf
multi_blkdr
noah_eta-my
Index of Agreement
px_acm2
noah_mrf
multi_blkdr
noah_eta-my
Jan 02
Jan 04
Jan 06
Jan 08
Jan 10
Jan 12
Jan 14
Jan 16
Jan 18
Jan 20
Jan 22

Spatial Statistical Plots

- **Station-specific statistical ranking**
  - px_acm noah_mrf multi_blkdr noah_eta-my
- **Best sensitivity displayed**
- **Hourly (Composite UTC day), Total stats available**
- **Bias, error, rmse (total only)**
- **Warning: Possibly little difference between "best" and "worst" sensitivity**

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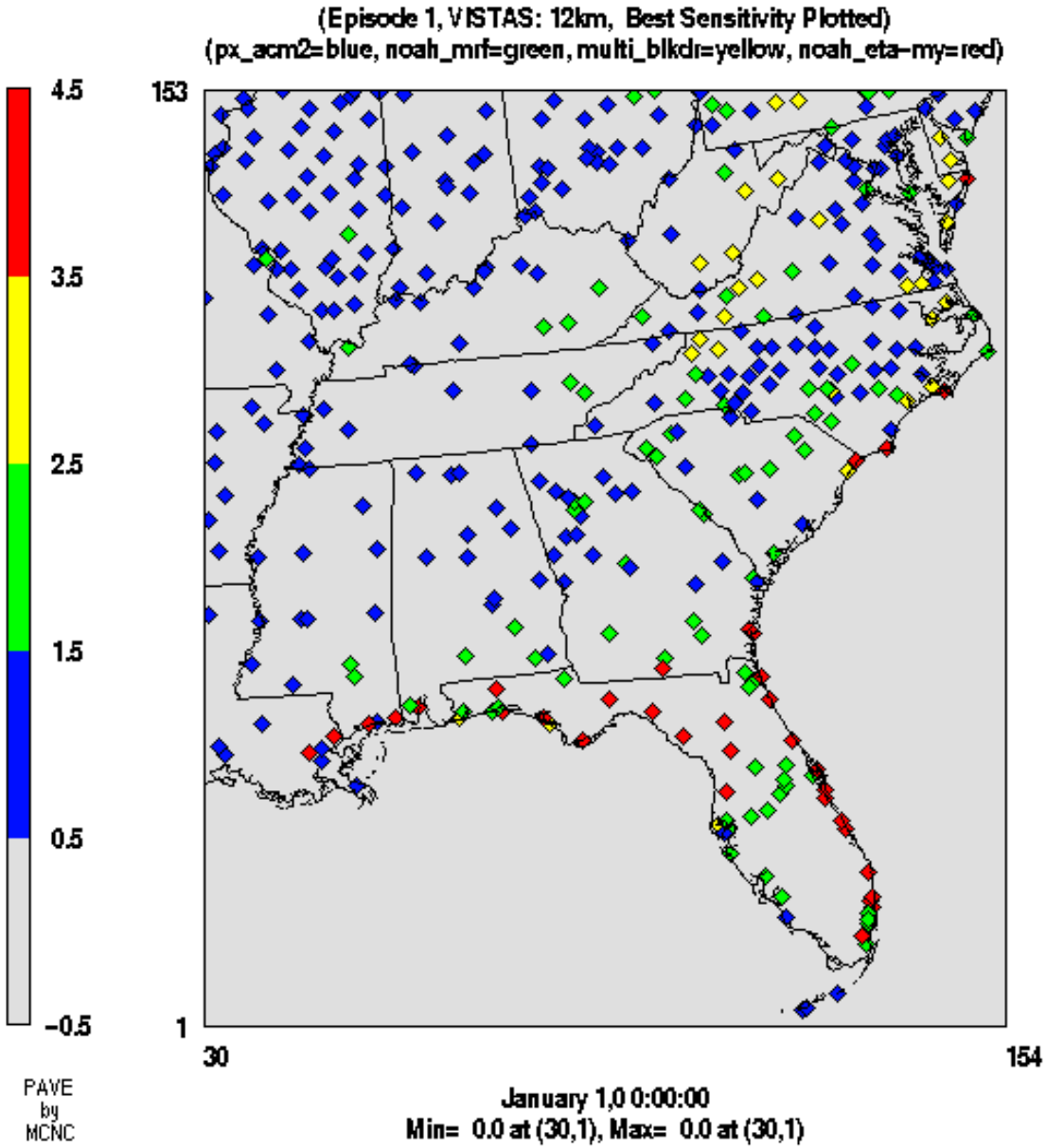
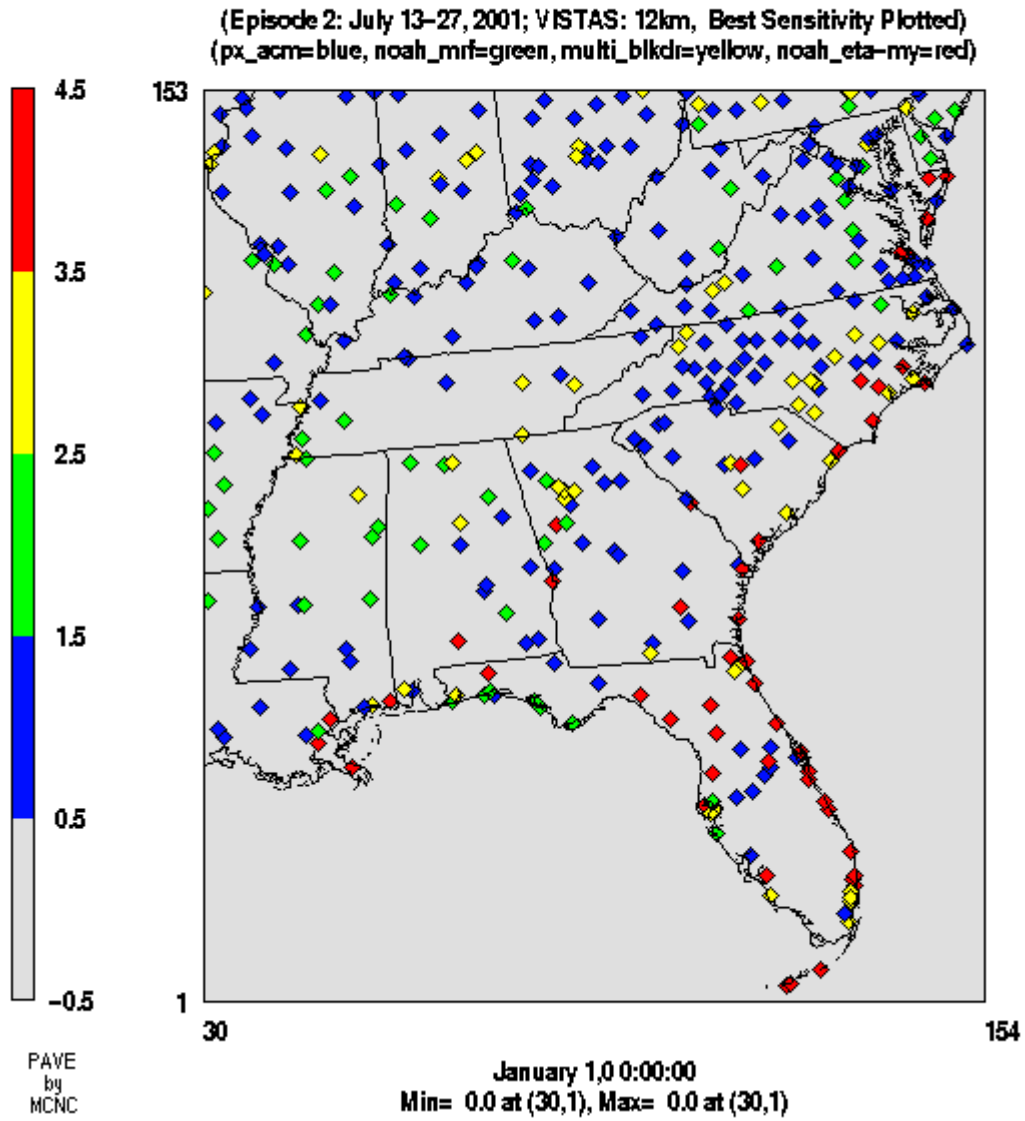
Total Cross–Sensitivity Temperature (1.5m) Error

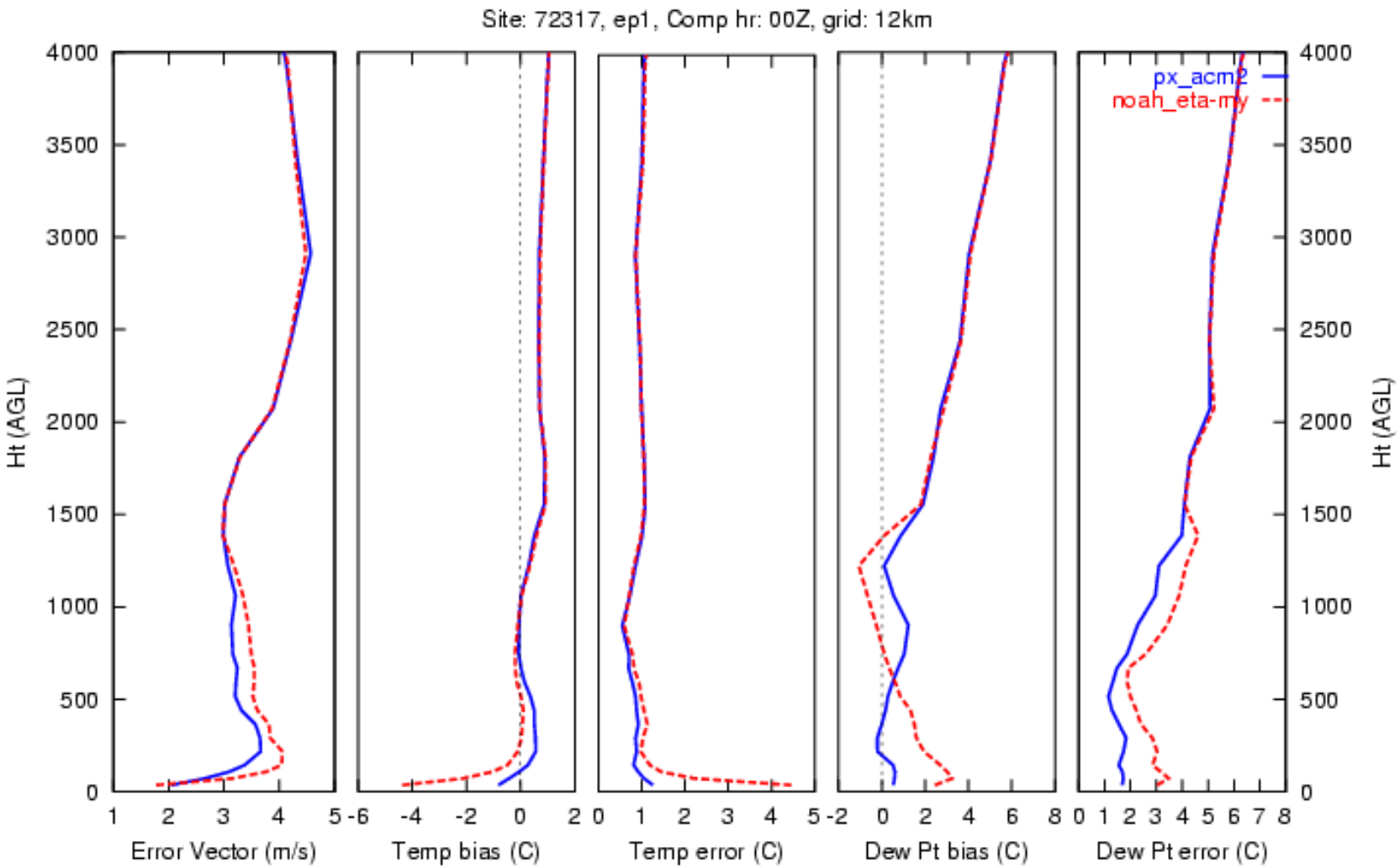


Total Cross–Sensitivity Temperature (1.5m) Error



Evaluation Summary

- px_acm2 statistically best overall
  - Winds best in noah_eta-my, especially at night (px_acm2 strong second best)
  - Temps best in px_acm2, worst in noah_eta-my
- Significant differences in PBL heights (noah_mrf > px_acm > noah_eta-my)
- noah_eta-my produces more precip (spatially) than the other schemes


Site: 72317, ep1, Comp hr: 00Z, grid: 12km
px_acm2
noah_eta-my
Ht (AGL)
Error Vector (m/s)
Temp bias (C)
Temp error (C)
Dew Pt bias (C)
Dew Pt error (C)

Auxiliary Sensitivity Tests

- **Limited analyses (statistical)**
- **Full winter/summer episodic runs**
- **Examines the following options**
  - **P-X soil initializations**
  - **Cloud parameterizations (KF2, KF, Grell)**
  - **Radiation schemes (Surface, cloud, ccm, rrtm)**
  - **Nudging options (strength, thermodynamic nudging in pbl)**
  - **Snow effects**
  - **Reisner 1 / Reisner 2 Microphysics**
  - **LITTLE_R vs RAWINS**

Winter Base Case (px_acm2) Stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-1.14	2.30	0.879	0.963	3.0613
Mixing Ratio (g/kg)	0.07	0.53	0.876	0.967	0.7673
Rel. Humidity (%)	3.54	12.62	0.451	0.814	16.4208
Wind Speed (m/s)	-0.02	1.33	0.510	0.808	1.7307
Clouds (%)	-4.00	26.12	0.340	0.763	37.6462

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	1.913	25.11	1.2520	1.2552	1.7729

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	0.8360	1.0061	0.2760	0.7284	0.5701	0.4379	0.6102	0.6091
0.05	0.9038	1.1156	0.3204	0.7581	0.5585	0.4914	0.6898	0.6590
0.10	0.9352	1.1405	0.3308	0.7632	0.5541	0.5115	0.7187	0.6768
0.25	0.9703	1.0628	0.2959	0.7484	0.5693	0.5502	0.7309	0.7099
0.50	0.9845	1.0006	0.3133	0.6872	0.5232	0.5140	0.6792	0.6790
1.00	0.9940	0.8873	0.3833	0.5472	0.4083	0.4054	0.5446	0.5769

Summer Base Case (px_acm2) Stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.16	1.62	0.877	0.964	2.1443
Mixing Ratio (g/kg)	-0.17	1.47	0.809	0.947	1.9714
Rel. Humidity (%)	-0.28	9.78	0.672	0.904	13.0680
Wind Speed (m/s)	-0.20	1.24	0.429	0.772	1.6149
Clouds (%)	1.38	27.52	0.134	0.635	37.9526

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	2.010	32.37	1.2469	1.3037	1.8040

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	0.7375	0.8822	0.2501	0.6616	0.5420	0.3067	0.4663	0.4694
0.05	0.7578	1.0815	0.4105	0.6376	0.4415	0.2794	0.4470	0.4368
0.10	0.7807	1.2392	0.5089	0.6085	0.3732	0.2511	0.4363	0.4014
0.25	0.8387	1.5406	0.6509	0.5378	0.2685	0.2008	0.4137	0.3345
0.50	0.9052	1.6829	0.7565	0.4098	0.1803	0.1482	0.3416	0.2582
1.00	0.9715	1.5577	0.8696	0.2030	0.0862	0.0782	0.1849	0.1450

Cross Sensitivity Stat Tables

- px_acm2 is normally the base case
- Stat differences are tabulated and color-coded
  - Green means the sensitivity being tested performs better; red means worse
  - Differences are calculated from optimum value
    - If IA (base) is 0.95, and IA (test) is 0.90, then -0.05 would be plotted in red. If IA (test) were 0.97, then 0.02 would be plotted in green.
    - If precip bias (base) is 0.90 and precip bias (test) is 1.08, then 0.02 would be plotted in green.

Winter px_acm stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.92	-0.60	-0.021	-0.017	-0.6456
Mixing Ratio (g/kg)	-0.01	0.00	-0.002	-0.001	0.0023
Rel. Humidity (%)	0.26	-0.08	-0.017	-0.006	-0.1239
Wind Speed (m/s)	-0.02	-0.03	-0.022	-0.015	-0.0392
Clouds (%)	-0.23	0.12	0.002	0.001	0.0373

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	0.424	-0.06	-0.0205	-0.0178	-0.0270

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	0.0035	-0.0140	0.0120	-0.0073	0.0028	0.0057	0.0008	0.0054
0.05	0.0023	0.0235	0.0104	-0.0045	0.0045	0.0057	-0.0010	0.0051
0.10	0.0014	0.0238	0.0097	-0.0051	0.0039	0.0045	-0.0029	0.0040
0.25	0.0006	0.0221	0.0103	-0.0049	0.0039	0.0042	-0.0038	0.0034
0.50	0.0000	-0.0111	0.0030	-0.0056	-0.0016	-0.0015	-0.0054	-0.0013
1.00	0.0000	-0.0051	-0.0010	-0.0041	-0.0027	-0.0028	-0.0040	-0.0028

Summer px_acm stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.04	0.05	0.004	0.002	0.0393
Mixing Ratio (g/kg)	-0.24	-0.04	0.003	-0.002	-0.0335
Rel. Humidity (%)	-1.56	-0.13	-0.003	-0.002	-0.2838
Wind Speed (m/s)	0.02	0.00	-0.001	0.000	-0.0004
Clouds (%)	0.06	-0.07	-0.002	-0.002	-0.0969

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-0.074	0.07	-0.0015	-0.0012	-0.0019

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	0.0026	-0.0124	0.0068	-0.0034	0.0012	0.0043	0.0045	0.0050
0.05	0.0031	0.0170	0.0063	-0.0034	0.0019	0.0038	0.0025	0.0046
0.10	0.0032	0.0169	0.0059	-0.0010	0.0030	0.0042	0.0033	0.0053
0.25	0.0032	0.0281	0.0066	0.0002	0.0040	0.0047	0.0038	0.0064
0.50	0.0014	0.0371	0.0027	-0.0047	0.0005	0.0008	-0.0030	0.0012
1.00	0.0004	0.0356	0.0006	-0.0036	-0.0003	-0.0003	-0.0032	-0.0005

Winter noah_mrf stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.14	-0.17	-0.012	-0.005	-0.1357
Mixing Ratio (g/kg)	0.01	0.04	0.009	0.002	0.0382
Rel. Humidity (%)	-0.40	0.22	0.006	0.000	0.3528
Wind Speed (m/s)	-0.13	-0.02	0.001	0.025	-0.0283
Clouds (%)	-2.68	-1.58	-0.042	-0.029	-1.4727

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-2.704	-0.27	-0.0108	-0.0156	-0.0187

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0153	-0.0554	-0.0359	0.0020	-0.0213	-0.0302	-0.0207	-0.0298
0.05	-0.0042	-0.0243	-0.0154	-0.0009	-0.0109	-0.0128	-0.0058	-0.0116
0.10	-0.0015	-0.0225	-0.0093	0.0042	-0.0042	-0.0050	0.0021	-0.0044
0.25	-0.0027	-0.0400	-0.0299	-0.0049	-0.0223	-0.0234	-0.0073	-0.0198
0.50	-0.0011	-0.0105	-0.0224	-0.0155	-0.0217	-0.0220	-0.0161	-0.0195
1.00	-0.0006	0.0437	-0.0464	-0.0162	-0.0290	-0.0293	-0.0167	-0.0303

Summer noah_mrf stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.37	-0.27	-0.021	-0.005	-0.3041
Mixing Ratio (g/kg)	-0.67	-0.05	0.017	-0.005	-0.0018
Rel. Humidity (%)	-2.50	-0.02	0.016	-0.002	0.3326
Wind Speed (m/s)	-0.31	-0.20	-0.104	-0.047	-0.2402
Clouds (%)	0.83	0.50	0.005	0.001	0.6075

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-1.086	-0.53	-0.0358	-0.0394	-0.0531

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0003	-0.0157	0.0042	-0.0082	-0.0034	-0.0009	-0.0015	-0.0010
0.05	0.0058	0.0206	0.0109	-0.0007	0.0058	0.0085	0.0079	0.0103
0.10	0.0076	0.0410	0.0145	-0.0027	0.0072	0.0100	0.0077	0.0127
0.25	0.0150	0.1450	0.0331	-0.0045	0.0179	0.0214	0.0130	0.0292
0.50	0.0151	0.3081	0.0500	-0.0064	0.0243	0.0272	0.0098	0.0403
1.00	0.0047	0.2763	0.0575	0.0378	0.0318	0.0324	0.0419	0.0542

Winter multi_blkdr stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.36	-0.22	-0.023	-0.010	-0.3301
Mixing Ratio (g/kg)	-0.31	-0.14	-0.033	-0.017	-0.1974
Rel. Humidity (%)	-11.03	-4.38	-0.080	-0.147	-5.0237
Wind Speed (m/s)	-0.26	-0.05	-0.002	0.024	-0.0604
Clouds (%)	2.38	-1.57	-0.042	-0.020	-1.3545

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-1.938	-0.38	-0.0476	-0.0389	-0.0611

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0282	-0.1382	0.0682	0.0220	-0.0318	-0.0495	-0.0275	-0.0496
0.05	-0.0058	-0.0490	0.0231	0.0065	-0.0124	-0.0152	-0.0017	-0.0138
0.10	-0.0028	-0.0385	0.0168	0.0060	-0.0085	-0.0099	0.0021	-0.0087
0.25	-0.0012	-0.0291	0.0154	0.0036	-0.0080	-0.0086	0.0023	-0.0072
0.50	-0.0004	-0.0099	0.0091	-0.0025	-0.0068	-0.0069	-0.0028	-0.0060
1.00	-0.0001	-0.0284	0.0009	-0.0183	-0.0106	-0.0106	-0.0182	-0.0108

Summer multi_blkdr stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.02	-0.14	-0.019	-0.006	-0.1609
Mixing Ratio (g/kg)	0.15	-0.02	-0.030	-0.010	-0.0399
Rel. Humidity (%)	-0.65	-0.48	-0.032	-0.021	-0.2737
Wind Speed (m/s)	0.10	-0.12	-0.073	-0.018	-0.1302
Clouds (%)	0.04	0.91	0.011	0.005	0.9705

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-0.841	-0.24	-0.0488	-0.0678	-0.0828

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0254	0.0395	0.0400	-0.0073	-0.0257	-0.0413	-0.0487	-0.0499
0.05	-0.0254	-0.0682	0.0421	-0.0083	-0.0276	-0.0377	-0.0411	-0.0475
0.10	-0.0229	-0.0816	0.0399	-0.0125	-0.0276	-0.0342	-0.0382	-0.0449
0.25	-0.0107	-0.0272	0.0284	-0.0350	-0.0250	-0.0263	-0.0426	-0.0373
0.50	0.0007	0.1146	0.0144	-0.0505	-0.0176	-0.0169	-0.0471	-0.0261
1.00	0.0023	0.1937	-0.0100	-0.0116	0.0019	0.0023	-0.0092	0.0040

Winter noah_eta-my stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-1.30	-0.90	-0.046	-0.030	-1.1408
Mixing Ratio (g/kg)	-0.06	-0.08	-0.022	-0.007	-0.0803
Rel. Humidity (%)	-10.88	-4.71	-0.077	-0.125	-5.2197
Wind Speed (m/s)	-0.06	0.03	0.026	0.028	0.0442
Clouds (%)	1.19	-0.98	-0.016	-0.011	-0.2897

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	0.668	0.35	0.0371	0.0318	0.0487

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0434	-0.2155	-0.0990	0.0351	-0.0465	-0.0732	-0.0418	-0.0747
0.05	-0.0015	-0.0123	-0.0063	0.0013	-0.0036	-0.0043	-0.0008	-0.0039
0.10	0.0003	0.0009	0.0015	0.0011	0.0017	0.0017	0.0013	0.0015
0.25	-0.0001	0.0093	0.0016	-0.0050	-0.0019	-0.0018	-0.0047	-0.0016
0.50	-0.0002	-0.0047	-0.0015	-0.0056	-0.0041	-0.0042	-0.0056	-0.0036
1.00	-0.0001	-0.0142	-0.0051	-0.0132	-0.0095	-0.0096	-0.0132	-0.0098

Summer noah_eta-my stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-1.15	-0.71	-0.043	-0.022	-0.8789
Mixing Ratio (g/kg)	0.00	0.05	0.009	0.003	0.0895
Rel. Humidity (%)	-5.67	-0.74	0.032	-0.008	-0.5429
Wind Speed (m/s)	-0.24	0.00	0.026	0.002	-0.0108
Clouds (%)	-0.54	0.45	-0.006	-0.008	0.2731

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	1.138	0.31	0.0335	0.0337	0.0475

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0176	0.1064	-0.0459	0.0344	-0.0036	-0.0269	-0.0293	-0.0321
0.05	-0.0149	-0.1029	-0.0288	0.0265	-0.0046	-0.0146	-0.0062	-0.0180
0.10	-0.0181	-0.1142	-0.0304	0.0150	-0.0128	-0.0197	-0.0122	-0.0255
0.25	-0.0085	-0.0389	-0.0208	-0.0193	-0.0169	-0.0182	-0.0264	-0.0256
0.50	0.0045	0.1814	-0.0016	-0.0465	-0.0104	-0.0091	-0.0393	-0.0139
1.00	0.0040	0.3590	0.0130	-0.0311	-0.0014	-0.0006	-0.0268	-0.0010

Sensitivity test: px_acm3

- **Like px_acm2, except:**
  - **soil moisture/temperature initialization for P-X soil layer 2 from EDAS soil layer 3 (40-100 cm).**

Winter px-acm3 stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.65	0.17	-0.002	0.003	0.2029
Mixing Ratio (g/kg)	0.05	0.00	-0.002	0.000	-0.0035
Rel. Humidity (%)	2.53	0.18	0.025	0.015	0.1032
Wind Speed (m/s)	-0.03	0.02	0.010	0.009	0.0192
Clouds (%)	-0.02	-0.01	0.001	0.000	0.0497

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-0.643	-0.02	0.0072	0.0026	0.0070

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0028	-0.0257	-0.0101	0.0082	-0.0014	-0.0038	0.0007	-0.0037
0.05	-0.0016	-0.0193	-0.0075	0.0047	-0.0026	-0.0034	0.0019	-0.0031
0.10	-0.0012	-0.0252	-0.0086	0.0069	-0.0023	-0.0030	0.0048	-0.0026
0.25	-0.0007	-0.0199	-0.0092	0.0039	-0.0038	-0.0041	0.0031	-0.0035
0.50	-0.0002	-0.0251	-0.0083	0.0086	0.0000	-0.0001	0.0082	-0.0001
1.00	0.0000	0.0152	-0.0014	0.0081	0.0039	0.0038	0.0081	0.0039

Summer px_acm3 stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.62	-0.23	-0.018	-0.007	-0.2704
Mixing Ratio (g/kg)	-0.25	-0.03	-0.006	-0.004	-0.0304
Rel. Humidity (%)	-0.09	-0.18	-0.009	-0.003	-0.2014
Wind Speed (m/s)	0.00	-0.01	-0.008	-0.005	-0.0114
Clouds (%)	0.15	0.06	0.001	0.001	-0.0039

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	0.147	0.07	-0.0061	-0.0036	-0.0068

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0068	-0.0401	0.0033	-0.0273	-0.0168	-0.0126	-0.0159	-0.0149
0.05	0.0005	0.0599	0.0060	-0.0292	-0.0110	-0.0069	-0.0160	-0.0085
0.10	0.0043	0.0794	0.0079	-0.0297	-0.0071	-0.0034	-0.0162	-0.0044
0.25	0.0075	0.1285	0.0101	-0.0305	-0.0022	0.0003	-0.0184	0.0004
0.50	0.0061	0.1842	0.0082	-0.0326	-0.0025	-0.0010	-0.0245	-0.0016
1.00	0.0031	0.2807	0.0104	-0.0232	-0.0004	0.0001	-0.0198	0.0003

Sensitivity test: px_acm4

- **Like px_acm2, except:**
  - **uses the SFCFDDA file from RAWINS and MMINPUT files processed using RAWINS data rather than REGRID data .**

Winter px-acm4 stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.08	0.07	0.004	0.002	0.0950
Mixing Ratio (g/kg)	-0.02	0.01	0.003	0.000	0.0093
Rel. Humidity (%)	-0.18	0.09	0.009	0.003	0.1488
Wind Speed (m/s)	0.02	-0.03	-0.024	-0.010	-0.0397
Clouds (%)	-0.22	-0.15	-0.006	-0.003	-0.2251

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-0.255	-0.62	-0.0339	-0.0300	-0.0452

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0033	-0.0153	-0.0087	0.0022	-0.0041	-0.0062	-0.0035	-0.0061
0.05	-0.0010	-0.0074	-0.0042	0.0004	-0.0026	-0.0031	-0.0009	-0.0028
0.10	-0.0010	-0.0073	-0.0050	-0.0009	-0.0039	-0.0044	-0.0018	-0.0038
0.25	-0.0001	0.0203	0.0032	-0.0110	-0.0043	-0.0042	-0.0104	-0.0036
0.50	0.0000	-0.0346	0.0079	-0.0170	-0.0055	-0.0054	-0.0165	-0.0048
1.00	0.0001	-0.0264	0.0130	-0.0051	0.0028	0.0028	-0.0049	0.0028

Summer px_acm4 stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.10	0.01	0.005	0.001	0.0265
Mixing Ratio (g/kg)	0.02	0.01	0.003	0.001	0.0200
Rel. Humidity (%)	0.18	0.22	0.016	0.005	0.3339
Wind Speed (m/s)	-0.01	-0.03	-0.030	-0.016	-0.0438
Clouds (%)	0.05	-0.13	-0.004	-0.003	-0.1747

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-0.087	-0.91	-0.0344	-0.0341	-0.0484

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	0.0027	-0.0096	0.0060	-0.0020	0.0018	0.0044	0.0048	0.0051
0.05	0.0030	0.0180	0.0063	-0.0040	0.0016	0.0036	0.0021	0.0043
0.10	0.0002	0.0281	0.0000	-0.0137	-0.0052	-0.0041	-0.0098	-0.0053
0.25	0.0033	0.0683	0.0031	-0.0193	-0.0031	-0.0019	-0.0132	-0.0026
0.50	0.0018	0.0780	-0.0014	-0.0213	-0.0050	-0.0044	-0.0182	-0.0068
1.00	0.0012	0.0465	0.0179	0.0211	0.0118	0.0118	0.0219	0.0202

Sensitivity test: px_acm5

- **Like px_acm2, except:**
  - **uses Reisner 2 microphysics rather than Reisner 1.**

Winter px-acm5 stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.12	0.07	0.003	0.002	0.0972
Mixing Ratio (g/kg)	-0.01	0.00	0.000	0.000	0.0004
Rel. Humidity (%)	-0.01	-0.06	-0.001	0.000	-0.0488
Wind Speed (m/s)	0.00	0.01	0.001	0.001	0.0018
Clouds (%)	2.28	0.95	0.024	0.017	0.6766

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-0.046	-0.01	0.0017	0.0008	0.0018

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	0.0031	-0.0799	0.0283	-0.0408	-0.0094	-0.0030	-0.0190	-0.0029
0.05	0.0033	0.0860	0.0247	-0.0329	-0.0025	0.0001	-0.0228	0.0001
0.10	0.0018	0.0700	0.0190	-0.0265	-0.0017	-0.0006	-0.0213	-0.0005
0.25	0.0007	0.0505	0.0169	-0.0186	-0.0002	0.0002	-0.0168	0.0001
0.50	-0.0003	-0.0442	0.0046	-0.0269	-0.0133	-0.0132	-0.0264	-0.0117
1.00	-0.0001	-0.0325	-0.0015	-0.0213	-0.0126	-0.0126	-0.0212	-0.0129

Summer px_acm5 stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.07	-0.03	-0.002	-0.001	-0.0285
Mixing Ratio (g/kg)	0.01	-0.02	-0.004	-0.002	-0.0248
Rel. Humidity (%)	-0.20	-0.12	-0.009	-0.003	-0.1517
Wind Speed (m/s)	-0.02	0.00	-0.001	-0.002	-0.0034
Clouds (%)	-0.30	-0.11	-0.001	0.000	-0.2593

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	0.122	-0.02	0.0000	-0.0005	-0.0003

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0066	-0.0324	0.0013	-0.0232	-0.0150	-0.0121	-0.0151	-0.0143
0.05	-0.0023	0.0426	0.0000	-0.0252	-0.0122	-0.0099	-0.0177	-0.0122
0.10	0.0006	0.0525	0.0006	-0.0250	-0.0092	-0.0072	-0.0175	-0.0092
0.25	0.0046	0.1108	0.0029	-0.0344	-0.0072	-0.0052	-0.0249	-0.0074
0.50	0.0060	0.1887	0.0071	-0.0354	-0.0037	-0.0022	-0.0272	-0.0034
1.00	0.0024	0.2219	0.0059	-0.0210	-0.0017	-0.0013	-0.0184	-0.0021

Sensitivity test: px_acm6

- **Like px_acm2, except:**
  - **analysis nudging strengths aloft for wind/temps are increased from 2.5E-4, 1.0E-4 (36/12 km) to 3.0E-4, 3.0E-4.**

Winter px-acm6 stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.01	0.00	0.000	0.000	0.0053
Mixing Ratio (g/kg)	0.00	0.00	0.000	0.000	-0.0009
Rel. Humidity (%)	0.07	0.07	0.003	0.002	0.0799
Wind Speed (m/s)	-0.02	0.00	-0.002	-0.002	-0.0041
Clouds (%)	-0.03	0.02	0.001	0.000	0.0167

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	0.145	-0.04	-0.0006	-0.0011	-0.0011

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	0.0001	0.0034	0.0010	-0.0014	-0.0003	0.0000	-0.0006	0.0000
0.05	0.0003	0.0041	0.0013	-0.0012	0.0002	0.0004	-0.0007	0.0003
0.10	0.0004	0.0025	0.0023	0.0009	0.0021	0.0021	0.0013	0.0019
0.25	0.0002	0.0000	0.0018	0.0019	0.0023	0.0024	0.0020	0.0019
0.50	-0.0001	-0.0105	-0.0025	0.0046	0.0012	0.0011	0.0045	0.0010
1.00	0.0000	0.0031	-0.0021	0.0000	-0.0009	-0.0010	0.0000	-0.0010

Summer px_acm6 stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.00	0.00	0.001	0.001	0.0059
Mixing Ratio (g/kg)	-0.01	-0.01	-0.002	-0.001	-0.0132
Rel. Humidity (%)	-0.06	0.01	0.001	0.001	0.0190
Wind Speed (m/s)	0.00	0.00	-0.001	-0.001	-0.0023
Clouds (%)	0.01	-0.14	-0.003	-0.003	-0.2124

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	0.026	-0.12	-0.0029	-0.0027	-0.0039

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0005	0.0045	-0.0019	0.0017	0.0002	-0.0007	-0.0008	-0.0008
0.05	-0.0023	-0.0094	-0.0042	0.0009	-0.0019	-0.0031	-0.0028	-0.0038
0.10	-0.0031	-0.0116	-0.0057	-0.0014	-0.0038	-0.0048	-0.0050	-0.0061
0.25	-0.0018	-0.0141	-0.0041	-0.0014	-0.0027	-0.0031	-0.0033	-0.0043
0.50	-0.0015	-0.0280	-0.0046	-0.0011	-0.0028	-0.0030	-0.0027	-0.0046
1.00	-0.0005	-0.0485	-0.0017	0.0037	-0.0001	-0.0002	0.0030	-0.0003

Sensitivity test: px_acm7

- **Like px_acm2, except:**
  - **SFCFDDA files from RAWINS are used instead of those from LITTLE_R.**

Winter px-acm7 stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.00	-0.01	0.000	0.000	-0.0029
Mixing Ratio (g/kg)	0.00	0.00	-0.001	0.000	-0.0009
Rel. Humidity (%)	-0.05	0.01	0.000	0.000	0.0095
Wind Speed (m/s)	0.00	-0.04	-0.028	-0.013	-0.0470
Clouds (%)	0.05	0.01	0.001	0.000	0.0226

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	0.017	-0.77	-0.0373	-0.0370	-0.0525

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0002	0.0014	0.0000	-0.0010	-0.0006	-0.0006	-0.0008	-0.0006
0.05	-0.0001	-0.0008	-0.0005	0.0000	-0.0003	-0.0003	-0.0001	-0.0003
0.10	0.0005	0.0020	0.0023	0.0013	0.0023	0.0024	0.0017	0.0021
0.25	0.0001	0.0022	0.0015	0.0000	0.0010	0.0010	0.0001	0.0008
0.50	-0.0001	-0.0000	-0.0003	-0.0013	-0.0010	-0.0010	-0.0012	-0.0008
1.00	0.0000	0.0152	-0.0025	0.0071	0.0028	0.0027	0.0071	0.0028

Summer px_acm7 stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.00	-0.01	-0.001	0.000	-0.0153
Mixing Ratio (g/kg)	0.06	0.01	0.003	0.000	0.0100
Rel. Humidity (%)	0.26	0.04	0.003	0.001	0.0765
Wind Speed (m/s)	-0.01	-0.04	-0.033	-0.018	-0.0484
Clouds (%)	-0.18	-0.13	-0.002	-0.002	-0.1188

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-0.023	-1.18	-0.0404	-0.0433	-0.0592

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0025	-0.0088	-0.0005	-0.0071	-0.0050	-0.0045	-0.0055	-0.0053
0.05	-0.0026	0.0117	-0.0031	-0.0103	-0.0066	-0.0065	-0.0097	-0.0080
0.10	-0.0043	0.0104	-0.0083	-0.0152	-0.0104	-0.0108	-0.0165	-0.0139
0.25	-0.0018	0.0062	-0.0060	-0.0114	-0.0063	-0.0064	-0.0119	-0.0090
0.50	-0.0012	-0.0166	-0.0047	-0.0039	-0.0033	-0.0035	-0.0050	-0.0053
1.00	-0.0002	-0.0326	0.0014	0.0066	0.0018	0.0017	0.0062	0.0030

Sensitivity test: px_acm8

- **Like px_acm2, except:**
  - **MMINPUT files are processed using data from LITTLE_R rather than from REGRID.**

Winter px-acm8 stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.22	0.15	0.008	0.004	0.1800
Mixing Ratio (g/kg)	-0.02	0.01	0.002	0.000	0.0076
Rel. Humidity (%)	0.35	0.32	0.021	0.010	0.4144
Wind Speed (m/s)	0.02	0.02	0.010	0.007	0.0180
Clouds (%)	0.03	0.05	0.003	0.001	0.1037

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-0.237	0.19	0.0098	0.0129	0.0161

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0043	-0.0168	-0.0107	0.0013	-0.0059	-0.0085	-0.0054	-0.0082
0.05	-0.0015	-0.0107	-0.0059	0.0007	-0.0036	-0.0043	-0.0012	-0.0039
0.10	-0.0009	-0.0110	-0.0055	0.0010	-0.0032	-0.0037	-0.0002	-0.0032
0.25	0.0003	0.0225	0.0078	-0.0078	0.0005	0.0008	-0.0069	0.0006
0.50	-0.0003	-0.0312	0.0004	-0.0220	-0.0126	-0.0126	-0.0217	-0.0111
1.00	0.0000	-0.0233	0.0014	-0.0132	-0.0068	-0.0068	-0.0131	-0.0069

Summer px_acm8 stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.06	0.07	0.011	0.003	0.0879
Mixing Ratio (g/kg)	0.00	0.00	0.002	0.000	0.0121
Rel. Humidity (%)	-0.13	0.23	0.014	0.005	0.3027
Wind Speed (m/s)	0.00	0.01	0.008	0.005	0.0113
Clouds (%)	0.33	0.19	0.004	0.002	0.2725

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-0.250	0.26	0.0091	0.0118	0.0148

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	0.0040	0.0122	0.0014	0.0104	0.0077	0.0074	0.0088	0.0086
0.05	0.0011	-0.0235	-0.0002	0.0136	0.0064	0.0052	0.0094	0.0063
0.10	-0.0018	-0.0272	-0.0032	0.0094	0.0016	0.0004	0.0045	0.0005
0.25	-0.0019	-0.0089	-0.0049	-0.0044	-0.0039	-0.0042	-0.0060	-0.0059
0.50	-0.0023	-0.0344	-0.0080	-0.0054	-0.0055	-0.0058	-0.0076	-0.0088
1.00	0.0002	-0.0058	0.0064	0.0109	0.0048	0.0048	0.0109	0.0082

Sensitivity test: px_acm9

- **Like px_acm2, except:**
  - **initialization for soil temperature/moisture is based on a 25% weighting of EDAS soil layer 1 (0-10 cm) values and a 75% weighting from EDAS soil layer 3 (40-100 cm). Code supplied by Aijun Xiu; executed for episode 3 only.**

Summer px_acm9 stats (Episode 3, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.42	-0.12	-0.009	-0.004	-0.1230
Mixing Ratio (g/kg)	-0.08	0.01	0.000	0.000	0.0113
Rel. Humidity (%)	0.00	-0.08	-0.006	-0.002	-0.0670
Wind Speed (m/s)	-0.01	-0.01	-0.005	-0.005	-0.0098
Clouds (%)	-0.09	-0.03	-0.002	0.000	-0.0983

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	0.139	0.05	-0.0036	-0.0039	-0.0053

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0049	-0.0160	-0.0015	-0.0132	-0.0098	-0.0084	-0.0108	-0.0105
0.05	0.0000	-0.0220	0.0020	-0.0125	-0.0052	-0.0033	-0.0072	-0.0043
0.10	0.0011	0.0376	0.0016	-0.0163	-0.0056	-0.0040	-0.0107	-0.0052
0.25	0.0034	0.0449	0.0062	-0.0062	0.0017	0.0027	-0.0017	0.0038
0.50	0.0019	0.0502	0.0047	-0.0031	0.0020	0.0024	-0.0009	0.0036
1.00	0.0013	0.1032	0.0068	0.0036	0.0039	0.0040	0.0049	0.0071

Sensitivity test: s0px_acm2

- **Like px_acm2, except:**
  - **snow cover effects are not considered (IFSNOW=0) as opposed to IFSNOW=1 in px_acm2. Run only for episode 1.**

Winter s0px-acm2 stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.07	0.03	0.000	0.001	0.0466
Mixing Ratio (g/kg)	-0.01	0.00	-0.001	0.000	-0.0007
Rel. Humidity (%)	-0.08	-0.02	0.000	0.000	-0.0138
Wind Speed (m/s)	0.01	0.01	0.001	0.001	0.0017
Clouds (%)	0.20	0.03	0.001	0.001	0.0607

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-0.040	-0.01	0.0007	0.0002	0.0007

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0014	-0.0095	-0.0044	0.0025	-0.0012	-0.0022	-0.0005	-0.0022
0.05	-0.0009	-0.0076	-0.0038	0.0010	-0.0021	-0.0025	-0.0004	-0.0023
0.10	-0.0003	-0.0057	-0.0020	0.0015	-0.0005	-0.0007	0.0010	-0.0006
0.25	-0.0001	-0.0003	-0.0006	-0.0005	-0.0006	-0.0006	-0.0005	-0.0006
0.50	-0.0001	-0.0013	0.0002	-0.0016	-0.0008	-0.0008	-0.0015	-0.0007
1.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Sensitivity test: s2px_acm2

- **Like px_acm2, except:**
  - **the simple snow model is employed (IFSNOW=2) as opposed to IFSNOW=1 in px_acm2. Run only for episode 1.**

Winter s2px-acm2 stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.91	-0.70	-0.046	-0.025	-0.9534
Mixing Ratio (g/kg)	0.02	-0.02	-0.016	-0.005	-0.0415
Rel. Humidity (%)	-0.03	-0.33	-0.048	-0.021	-0.5583
Wind Speed (m/s)	0.00	-0.02	-0.019	-0.011	-0.0332
Clouds (%)	-0.13	0.17	0.004	0.002	0.1250

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	0.189	-0.09	-0.0204	-0.0149	-0.0249

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	0.0035	-0.0093	0.0109	-0.0048	0.0037	0.0064	0.0023	0.0061
0.05	0.0017	0.0188	0.0078	-0.0042	0.0029	0.0038	-0.0014	0.0034
0.10	0.0011	0.0164	0.0069	-0.0032	0.0031	0.0035	-0.0016	0.0031
0.25	0.0004	0.0180	0.0077	-0.0047	0.0023	0.0025	-0.0039	0.0020
0.50	-0.0001	-0.0105	0.0016	-0.0065	-0.0029	-0.0029	-0.0064	-0.0025
1.00	0.0000	-0.0091	0.0006	-0.0051	-0.0025	-0.0026	-0.0050	-0.0026

Sensitivity test: n0_px_acm2

- **Like px_acm2, except:**
  - **soil moisture nudging is turned off.**

Summer n0_px_acm2 stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.09	-0.07	-0.010	-0.002	-0.0789
Mixing Ratio (g/kg)	-0.08	-0.09	-0.021	-0.007	-0.1060
Rel. Humidity (%)	-0.51	-0.45	-0.018	-0.006	-0.4458
Wind Speed (m/s)	0.00	0.00	-0.002	-0.001	-0.0039
Clouds (%)	0.04	0.00	0.000	-0.001	0.0099

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-0.048	-0.12	-0.0029	-0.0032	-0.0043

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0030	-0.0048	-0.0022	-0.0056	-0.0049	-0.0052	-0.0063	-0.0061
0.05	-0.0013	0.0071	-0.0014	-0.0057	-0.0035	-0.0033	-0.0051	-0.0041
0.10	-0.0013	0.0051	-0.0026	-0.0056	-0.0036	-0.0036	-0.0058	-0.0046
0.25	0.0002	0.0279	-0.0022	-0.0130	-0.0045	-0.0041	-0.0111	-0.0058
0.50	0.0014	0.0497	0.0006	-0.0111	-0.0019	-0.0015	-0.0090	-0.0023
1.00	0.0009	0.0776	0.0014	-0.0079	-0.0008	-0.0007	-0.0071	-0.0012

Sensitivity test: px_acm_n

- **Like px_acm_n, except:**
  - **surface analysis nudging is turned on for temp/moisture at a strength of 2.5E-4, 1.0E-4 (36, 12 km temps) and 1.0E-4, 1.0E-4 (36, 12 km moisture).**

Winter px-acm_n stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.27	0.47	0.039	0.012	0.5621
Mixing Ratio (g/kg)	-0.07	0.17	0.065	0.017	0.2255
Rel. Humidity (%)	0.38	4.66	0.293	0.105	5.9568
Wind Speed (m/s)	-0.05	0.04	0.025	0.014	0.0433
Clouds (%)	0.26	-0.04	-0.002	0.000	-0.0581

Wind stats	bias	abserr	Uerr	verr	uverr
Wind (deg, m/s)	-0.586	0.07	0.0133	0.0093	0.0160

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0018	-0.0310	-0.0095	0.0126	0.0016	-0.0007	0.0047	-0.0007
0.05	-0.0049	-0.0512	-0.0211	0.0102	-0.0091	-0.0117	0.0023	-0.0106
0.10	-0.0027	-0.0503	-0.0180	0.0122	-0.0062	-0.0077	0.0077	-0.0068
0.25	-0.0008	-0.0434	-0.0148	0.0141	-0.0018	-0.0023	0.0126	-0.0019
0.50	-0.0003	-0.0328	-0.0101	0.0120	0.0009	0.0008	0.0115	0.0007
1.00	-0.0002	0.0406	-0.0171	0.0091	-0.0027	-0.0028	0.0089	-0.0029

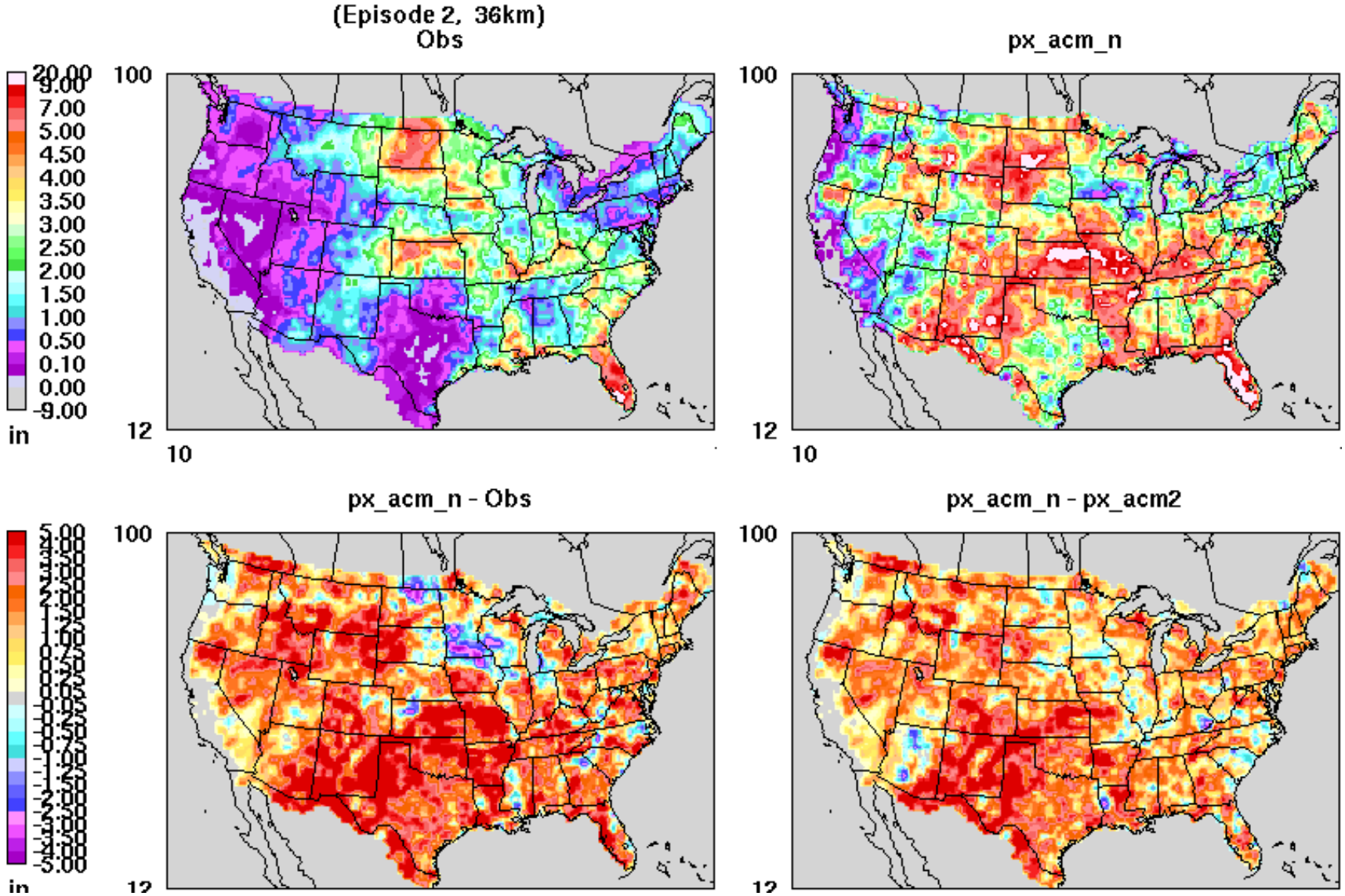
Summer px_acm_n stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.02	0.21	0.029	0.009	0.2498
Mixing Ratio (g/kg)	-0.45	0.34	0.080	0.018	0.4189
Rel. Humidity (%)	-3.58	2.54	0.174	0.042	3.5250
Wind Speed (m/s)	0.06	0.01	0.002	0.009	0.0041
Clouds (%)	-0.56	-0.79	-0.020	-0.021	-0.4014

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	0.106	-0.41	-0.0204	-0.0090	-0.0206

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0874	-0.3281	-0.1617	0.1888	-0.0090	-0.1196	-0.1430	-0.1542
0.05	-0.1698	-0.9034	-0.1832	0.1689	-0.0712	-0.1464	-0.1463	-0.2021
0.10	-0.1863	-1.1667	-0.1762	0.1491	-0.0871	-0.1379	-0.1289	-0.1980
0.25	-0.1372	-1.4409	-0.1362	0.0971	-0.0788	-0.0992	-0.0691	-0.1501
0.50	-0.0651	-1.3678	-0.0949	0.0436	-0.0543	-0.0616	-0.0274	-0.0987
1.00	-0.0131	-1.0558	-0.0411	0.0305	-0.0171	-0.0187	0.0167	-0.0327

Total Precipitation



Sensitivity test: px_acm_n2

- **Like px_acm2, except:**
  - **surface analysis nudging for moisture is reduced to 1.0E-5, 1.0E-5 (36, 12 km). Run only for episode 2.**

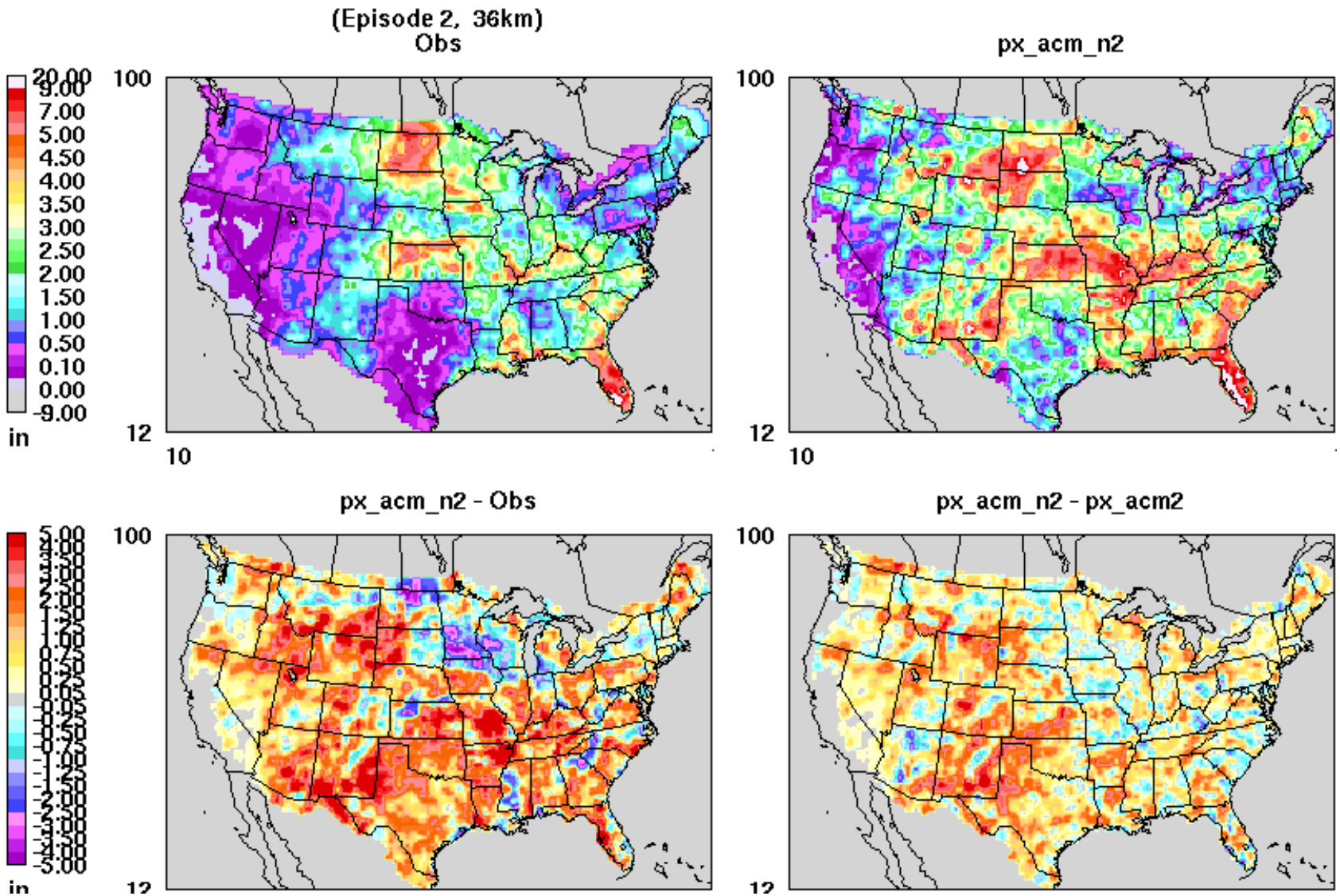
Summer px_acm_n2 stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.11	0.26	0.034	0.011	0.3233
Mixing Ratio (g/kg)	0.05	0.09	0.016	0.005	0.1248
Rel. Humidity (%)	-0.94	1.85	0.114	0.036	2.6266
Wind Speed (m/s)	0.08	0.01	0.004	0.012	0.0078
Clouds (%)	0.83	-0.44	-0.017	-0.015	-0.4841

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-0.162	-0.51	-0.0240	-0.0119	-0.0252

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0431	-0.0421	-0.0993	0.0930	-0.0051	-0.0628	-0.0705	-0.0772
0.05	-0.0849	-0.4172	-0.1192	0.0673	-0.0485	-0.0898	-0.0829	-0.1180
0.10	-0.0867	-0.4984	-0.1138	0.0470	-0.0584	-0.0857	-0.0763	-0.1175
0.25	-0.0545	-0.5351	-0.0804	0.0199	-0.0470	-0.0570	-0.0437	-0.0831
0.50	-0.0236	-0.4618	-0.0528	-0.0009	-0.0308	-0.0341	-0.0257	-0.0533
1.00	-0.0040	-0.3357	-0.0159	0.0138	-0.0052	-0.0059	0.0094	-0.0101

Total Precipitation



Sensitivity test: g1px_acm2

- **Like px_acm2, except:**
  - **Grell cumulus parameterization replaces KF2.**

Winter g1px-acm2 stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.06	0.03	0.001	0.000	0.0380
Mixing Ratio (g/kg)	-0.03	-0.01	-0.002	-0.001	-0.0153
Rel. Humidity (%)	-0.41	-0.12	-0.005	-0.003	-0.1239
Wind Speed (m/s)	0.01	0.00	-0.001	0.000	-0.0009
Clouds (%)	1.38	0.42	0.012	0.008	0.3882

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-0.166	-0.04	-0.0007	-0.0018	-0.0018

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0303	-0.1749	-0.0762	0.0367	-0.0297	-0.0500	-0.0222	-0.0501
0.05	-0.0146	-0.1167	-0.0541	0.0127	-0.0311	-0.0379	-0.0072	-0.0350
0.10	-0.0069	-0.0768	-0.0376	0.0057	-0.0232	-0.0263	-0.0027	-0.0234
0.25	-0.0030	-0.0016	-0.0268	-0.0275	-0.0327	-0.0338	-0.0291	-0.0288
0.50	-0.0016	-0.0742	-0.0178	-0.0683	-0.0495	-0.0497	-0.0681	-0.0448
1.00	-0.0006	-0.1787	-0.0293	-0.1310	-0.0862	-0.0861	-0.1306	-0.0929

Summer g1px_acm2 stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.13	0.01	0.003	0.002	0.0314
Mixing Ratio (g/kg)	0.13	-0.06	0.002	-0.001	-0.0454
Rel. Humidity (%)	0.02	0.01	0.014	0.005	0.1456
Wind Speed (m/s)	0.01	0.00	0.002	0.001	0.0035
Clouds (%)	-10.45	-4.95	-0.031	-0.029	-6.5085

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-0.309	-0.25	-0.0060	-0.0066	-0.0090

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0082	-0.1377	0.0345	-0.0776	-0.0388	-0.0176	-0.0244	-0.0209
0.05	0.0325	-0.1472	0.1062	-0.1010	-0.0069	0.0246	-0.0112	0.0295
0.10	0.0497	0.0432	0.1391	-0.1018	0.0174	0.0460	-0.0108	0.0568
0.25	0.0529	0.4407	0.1596	-0.0799	0.0490	0.0663	-0.0105	0.0871
0.50	0.0292	0.6325	0.1181	-0.0299	0.0471	0.0537	0.0023	0.0777
1.00	0.0022	0.0573	0.0392	0.0515	0.0271	0.0272	0.0529	0.0457

Sensitivity test: k1px_acm2

- **Like px_acm2, except:**
  - **Kain-Fritsch cumulus parameterization is used instead of Kain-Fritsch. Run for episode 2 only.**

Summer k1px-acm2 stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.33	-0.17	-0.034	-0.011	-0.3146
Mixing Ratio (g/kg)	-0.13	0.01	-0.004	-0.002	0.0226
Rel. Humidity (%)	-0.48	-0.76	-0.061	-0.021	-1.3117
Wind Speed (m/s)	-0.04	-0.01	-0.009	-0.006	-0.0190
Clouds (%)	0.98	0.63	0.010	0.008	0.3314

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	0.167	-0.10	-0.0049	-0.0029	-0.0054

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0274	0.0358	-0.0415	-0.0113	-0.0290	-0.0447	-0.0530	-0.0542
0.05	-0.0291	-0.0910	-0.0482	-0.0030	-0.0288	-0.0412	-0.0433	-0.0520
0.10	-0.0313	-0.1588	-0.0512	0.0065	-0.0283	-0.0387	-0.0352	-0.0510
0.25	-0.0294	-0.2800	-0.0501	0.0065	-0.0294	-0.0351	-0.0273	-0.0503
0.50	-0.0166	-0.2928	-0.0446	-0.0169	-0.0282	-0.0304	-0.0336	-0.0475
1.00	-0.0028	-0.1957	-0.0200	-0.0094	-0.0106	-0.0110	-0.0122	-0.0191

Sensitivity test: r1px_acm2

- **Like px_acm2, except:**
  - **Simple (surface) radiation scheme is used instead of RRTM.**

Winter r1px-acm2 stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.58	-0.31	-0.001	-0.007	-0.3004
Mixing Ratio (g/kg)	0.02	0.01	0.000	0.000	0.0018
Rel. Humidity (%)	-0.12	-0.29	-0.038	-0.017	-0.2959
Wind Speed (m/s)	-0.04	-0.02	-0.017	-0.013	-0.0311
Clouds (%)	-1.44	-0.25	-0.010	-0.006	-0.4534

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	0.490	-0.10	-0.0100	-0.0137	-0.0167

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	0.0067	-0.0513	0.0270	-0.0205	0.0032	0.0095	-0.0022	0.0091
0.05	0.0040	0.0395	0.0180	-0.0075	0.0078	0.0100	-0.0014	0.0089
0.10	0.0022	0.0307	0.0142	-0.0048	0.0071	0.0081	-0.0017	0.0070
0.25	0.0005	0.0194	0.0091	-0.0043	0.0034	0.0037	-0.0034	0.0030
0.50	0.0000	-0.0093	0.0023	-0.0050	-0.0016	-0.0015	-0.0048	-0.0013
1.00	0.0000	0.0010	-0.0018	-0.0010	-0.0013	-0.0014	-0.0010	-0.0014

Summer r1px_acm2 stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.86	-0.32	-0.011	-0.012	-0.3278
Mixing Ratio (g/kg)	-0.06	-0.02	-0.005	-0.002	-0.0187
Rel. Humidity (%)	-0.41	-0.70	-0.041	-0.015	-0.7381
Wind Speed (m/s)	-0.04	-0.02	-0.014	-0.014	-0.0249
Clouds (%)	0.90	0.53	0.002	0.001	0.2680

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	0.477	-0.09	-0.0107	-0.0098	-0.0145

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0204	-0.1215	0.0113	-0.0825	-0.0519	-0.0376	-0.0480	-0.0453
0.05	0.0004	-0.0097	0.0177	-0.0858	-0.0348	-0.0222	-0.0484	-0.0276
0.10	0.0072	0.2187	0.0144	-0.0926	-0.0303	-0.0201	-0.0583	-0.0262
0.25	0.0137	0.3192	0.0114	-0.0975	-0.0213	-0.0151	-0.0701	-0.0212
0.50	0.0124	0.4211	0.0108	-0.0890	-0.0150	-0.0115	-0.0712	-0.0176
1.00	0.0053	0.5055	0.0116	-0.0536	-0.0077	-0.0065	-0.0476	-0.0112

Sensitivity test: r2px_acm2

- **Like px_acm2, except:**
  - **Uses cloud (Dudhia) radiation scheme rather than RRTM.**

Winter r2px-acm2 stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.08	0.01	0.002	0.001	0.0177
Mixing Ratio (g/kg)	-0.01	0.00	0.000	0.000	-0.0049
Rel. Humidity (%)	-0.51	-0.03	0.011	0.003	0.0145
Wind Speed (m/s)	-0.01	0.01	0.002	0.001	0.0040
Clouds (%)	-0.01	-0.04	-0.002	-0.001	-0.0786

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	0.102	0.04	0.0029	0.0041	0.0050

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	0.0011	0.0052	0.0035	-0.0016	0.0012	0.0021	0.0007	0.0020
0.05	0.0004	0.0021	0.0013	0.0001	0.0009	0.0011	0.0005	0.0010
0.10	0.0004	0.0012	0.0020	0.0015	0.0022	0.0022	0.0018	0.0020
0.25	0.0000	0.0009	0.0003	-0.0003	0.0001	0.0001	-0.0002	0.0000
0.50	0.0000	-0.0022	0.0001	0.0015	0.0009	0.0009	0.0015	0.0008
1.00	0.0000	0.0081	-0.0022	0.0031	0.0008	0.0007	0.0030	0.0007

Summer r2px_acm2 stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.38	-0.18	-0.015	-0.007	-0.1871
Mixing Ratio (g/kg)	0.11	-0.05	-0.009	-0.003	-0.0605
Rel. Humidity (%)	-0.87	0.05	0.003	0.000	0.1193
Wind Speed (m/s)	0.03	0.01	0.005	0.007	0.0080
Clouds (%)	0.55	0.11	-0.001	-0.003	0.2064

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-0.695	-0.09	0.0012	0.0021	0.0023

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	0.0008	0.0217	-0.0050	0.0117	0.0052	0.0020	0.0029	0.0024
0.05	-0.0030	-0.0430	-0.0078	0.0165	0.0033	-0.0001	0.0051	-0.0002
0.10	-0.0048	-0.0681	-0.0082	0.0228	0.0035	0.0003	0.0104	0.0004
0.25	-0.0074	-0.1230	-0.0091	0.0278	0.0011	-0.0011	0.0161	-0.0016
0.50	-0.0080	-0.2153	-0.0124	0.0289	-0.0019	-0.0034	0.0189	-0.0052
1.00	-0.0041	-0.3741	-0.0103	0.0291	-0.0002	-0.0010	0.0244	-0.0016

Sensitivity test: r3px_acm2

- **Like px_acm2, except:**
  - **Uses CCM2 radiation instead of RRTM.**

Winter r3px-acm2 stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.78	-0.53	-0.016	-0.015	-0.6858
Mixing Ratio (g/kg)	0.07	-0.01	-0.002	-0.001	-0.0078
Rel. Humidity (%)	0.42	0.02	-0.014	-0.004	-0.0024
Wind Speed (m/s)	0.01	-0.01	-0.010	-0.005	-0.0168
Clouds (%)	0.02	0.17	0.004	0.003	0.0969

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	0.067	-0.08	-0.0113	-0.0130	-0.0172

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	0.0012	0.0050	0.0032	-0.0004	0.0017	0.0025	0.0015	0.0024
0.05	0.0008	0.0042	0.0027	0.0002	0.0019	0.0023	0.0010	0.0020
0.10	0.0009	0.0064	0.0045	0.0009	0.0036	0.0039	0.0017	0.0034
0.25	0.0001	0.0035	0.0020	-0.0005	0.0010	0.0011	-0.0003	0.0008
0.50	-0.0001	-0.0031	-0.0021	0.0000	-0.0012	-0.0013	-0.0001	-0.0011
1.00	0.0000	0.0061	-0.0008	0.0031	0.0014	0.0013	0.0030	0.0013

Summer r3px_acm2 stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.25	-0.05	-0.006	-0.001	-0.0755
Mixing Ratio (g/kg)	0.00	0.02	0.003	0.001	0.0249
Rel. Humidity (%)	0.19	-0.05	-0.005	-0.002	-0.0882
Wind Speed (m/s)	0.01	0.00	-0.005	-0.003	-0.0063
Clouds (%)	-0.30	0.05	0.004	0.003	0.1060

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	0.014	-0.02	-0.0051	-0.0053	-0.0073

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	0.0002	0.0115	-0.0030	0.0060	0.0024	0.0007	0.0011	0.0008
0.05	-0.0032	-0.0120	-0.0058	0.0007	-0.0029	-0.0044	-0.0041	-0.0055
0.10	-0.0018	-0.0105	-0.0034	0.0009	-0.0017	-0.0023	-0.0017	-0.0030
0.25	0.0014	0.0211	0.0020	-0.0044	0.0001	0.0005	-0.0023	0.0007
0.50	0.0035	0.1348	-0.0004	-0.0335	-0.0070	-0.0060	-0.0281	-0.0093
1.00	0.0036	0.3140	0.0148	-0.0224	0.0013	0.0020	-0.0186	0.0035

A little RTOFS departure . . .

Sensitivity test: noah_mrf4

- **Like noah_mrf, except:**
  - **Yubao version of the mrf scheme.**

Winter noah-mrf4 stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.55	-0.23	-0.003	-0.007	-0.2867
Mixing Ratio (g/kg)	-0.11	-0.05	-0.006	-0.002	-0.0362
Rel. Humidity (%)	-8.59	-3.80	-0.059	-0.097	-4.1300
Wind Speed (m/s)	0.00	0.05	0.026	0.003	0.0700
Clouds (%)	2.69	0.46	0.021	0.014	0.9992

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	0.529	0.49	0.0264	0.0355	0.0438

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0035	-0.0139	-0.0078	0.0012	-0.0044	-0.0064	-0.0043	-0.0065
0.05	0.0025	0.0304	0.0116	-0.0074	0.0038	0.0052	-0.0030	0.0047
0.10	0.0018	0.0293	0.0116	-0.0061	0.0048	0.0056	-0.0035	0.0050
0.25	0.0019	0.0410	0.0236	-0.0026	0.0139	0.0148	-0.0005	0.0125
0.50	0.0010	-0.0164	0.0271	0.0006	0.0156	0.0160	0.0016	0.0142
1.00	0.0004	-0.0549	0.0334	-0.0021	0.0133	0.0135	-0.0016	0.0142

Summer noah_mrf4 stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.50	-0.21	-0.007	-0.007	-0.2587
Mixing Ratio (g/kg)	0.58	0.06	-0.011	0.006	0.0279
Rel. Humidity (%)	-2.38	-0.60	0.010	-0.005	-0.5744
Wind Speed (m/s)	0.31	0.18	0.091	0.042	0.2203
Clouds (%)	-1.54	-0.08	-0.011	-0.010	-0.3203

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	0.468	0.54	0.0311	0.0357	0.0472

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0064	0.1141	-0.0365	0.0502	0.0124	-0.0080	-0.0063	-0.0094
0.05	-0.0184	-0.1460	-0.0375	0.0425	-0.0026	-0.0159	-0.0020	-0.0195
0.10	-0.0222	-0.1829	-0.0384	0.0395	-0.0086	-0.0186	0.0003	-0.0238
0.25	-0.0200	-0.2106	-0.0411	0.0145	-0.0203	-0.0250	-0.0098	-0.0343
0.50	-0.0103	-0.1969	-0.0385	-0.0026	-0.0200	-0.0220	-0.0134	-0.0324
1.00	-0.0005	0.0182	-0.0186	-0.0269	-0.0136	-0.0136	-0.0269	-0.0223

Sensitivity test: noah_mrf4d

- **Like noah_mrf4, except:**
  - **Modified certain PBL-related parameters to obtain higher PBL heights than noah_mrf4 (but lower than noah_mrf).**

Winter noah-mrf4d stats (Episode 1, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.06	0.01	-0.003	0.000	0.0098
Mixing Ratio (g/kg)	0.10	0.04	0.008	0.003	0.0418
Rel. Humidity (%)	2.60	1.57	0.028	0.040	1.6953
Wind Speed (m/s)	-0.10	0.00	0.005	0.006	-0.0106
Clouds (%)	-0.79	-0.14	-0.004	-0.005	-0.1215

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-0.262	-0.13	-0.0126	-0.0149	-0.0194

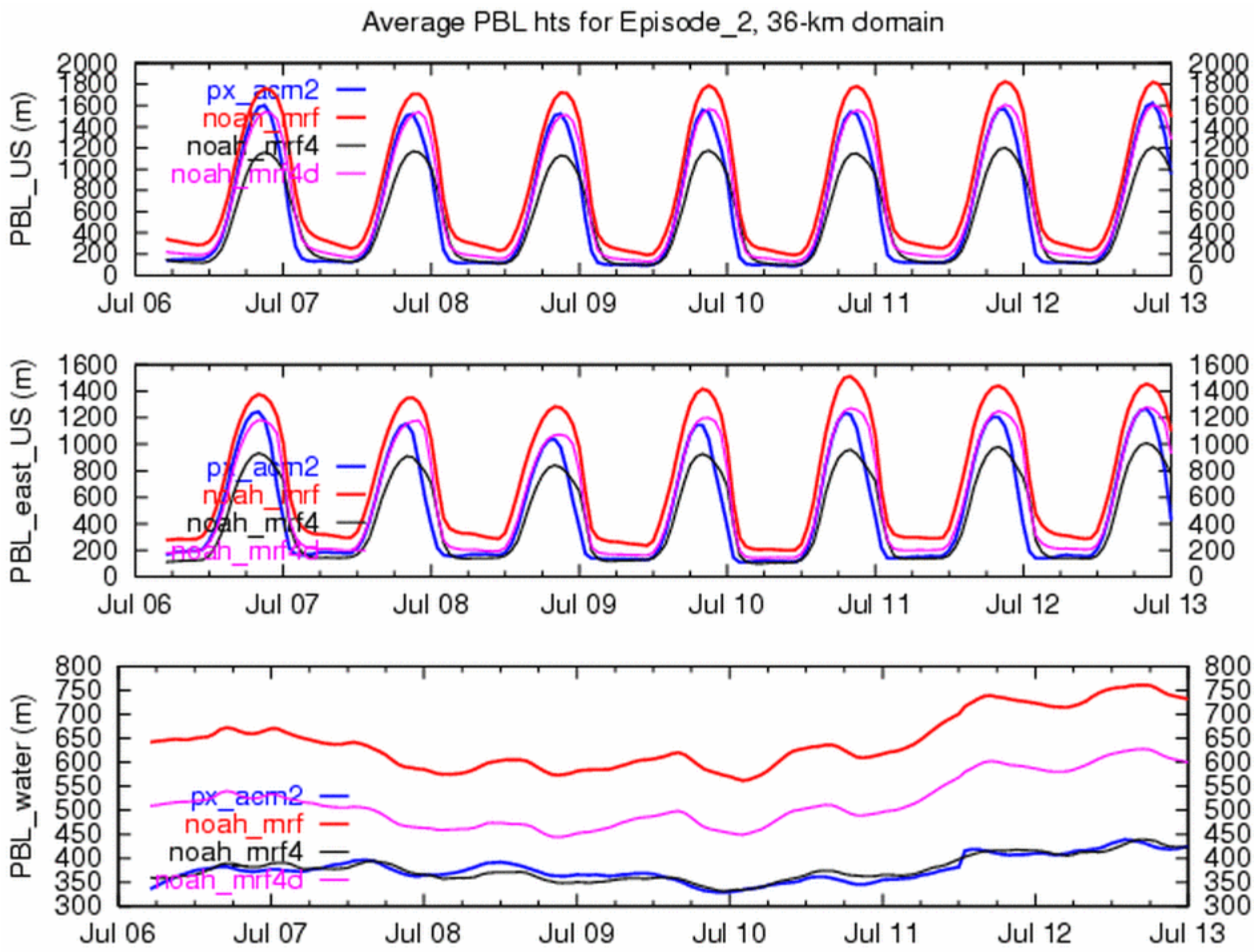
Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	-0.0096	-0.0455	-0.0216	0.0067	-0.0104	-0.0162	-0.0098	-0.0167
0.05	-0.0049	-0.0450	-0.0203	0.0070	-0.0099	-0.0124	-0.0002	-0.0113
0.10	-0.0021	-0.0335	-0.0133	0.0069	-0.0055	-0.0065	0.0039	-0.0058
0.25	-0.0011	-0.0333	-0.0155	0.0063	-0.0066	-0.0071	0.0048	-0.0060
0.50	-0.0004	0.0219	-0.0128	0.0025	-0.0057	-0.0060	0.0020	-0.0052
1.00	-0.0002	-0.0071	-0.0149	-0.0172	-0.0156	-0.0157	-0.0173	-0.0165

Summer noah_mrf4d stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	0.12	0.01	-0.002	0.001	0.0153
Mixing Ratio (g/kg)	0.10	0.05	0.003	0.002	0.0708
Rel. Humidity (%)	2.86	0.83	0.006	0.013	0.9292
Wind Speed (m/s)	0.02	0.01	0.007	0.007	0.0109
Clouds (%)	0.75	-0.04	0.004	0.003	0.1620

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-0.297	-0.02	-0.0007	0.0040	0.0024

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	0.0073	-0.0336	0.0159	-0.0090	0.0036	0.0116	0.0127	0.0136
0.05	0.0090	0.0444	0.0152	-0.0074	0.0062	0.0109	0.0085	0.0134
0.10	0.0100	0.0640	0.0163	-0.0085	0.0072	0.0109	0.0067	0.0141
0.25	0.0098	0.0821	0.0207	0.0036	0.0134	0.0153	0.0141	0.0211
0.50	0.0049	0.0713	0.0207	0.0128	0.0136	0.0144	0.0174	0.0212
1.00	0.0005	-0.0095	0.0182	0.0247	0.0129	0.0129	0.0248	0.0212


Average PBL hts for Episode_2, 36-km domain
PBL_US (m)
PBL_east_US (m)
PBL_water (m)
px_acm2
noah_mrf
noah_mrf4
noah_mrf4d
Jul 06
Jul 07
Jul 08
Jul 09
Jul 10
Jul 11
Jul 12
Jul 13

Sensitivity test: noah_mrf4f

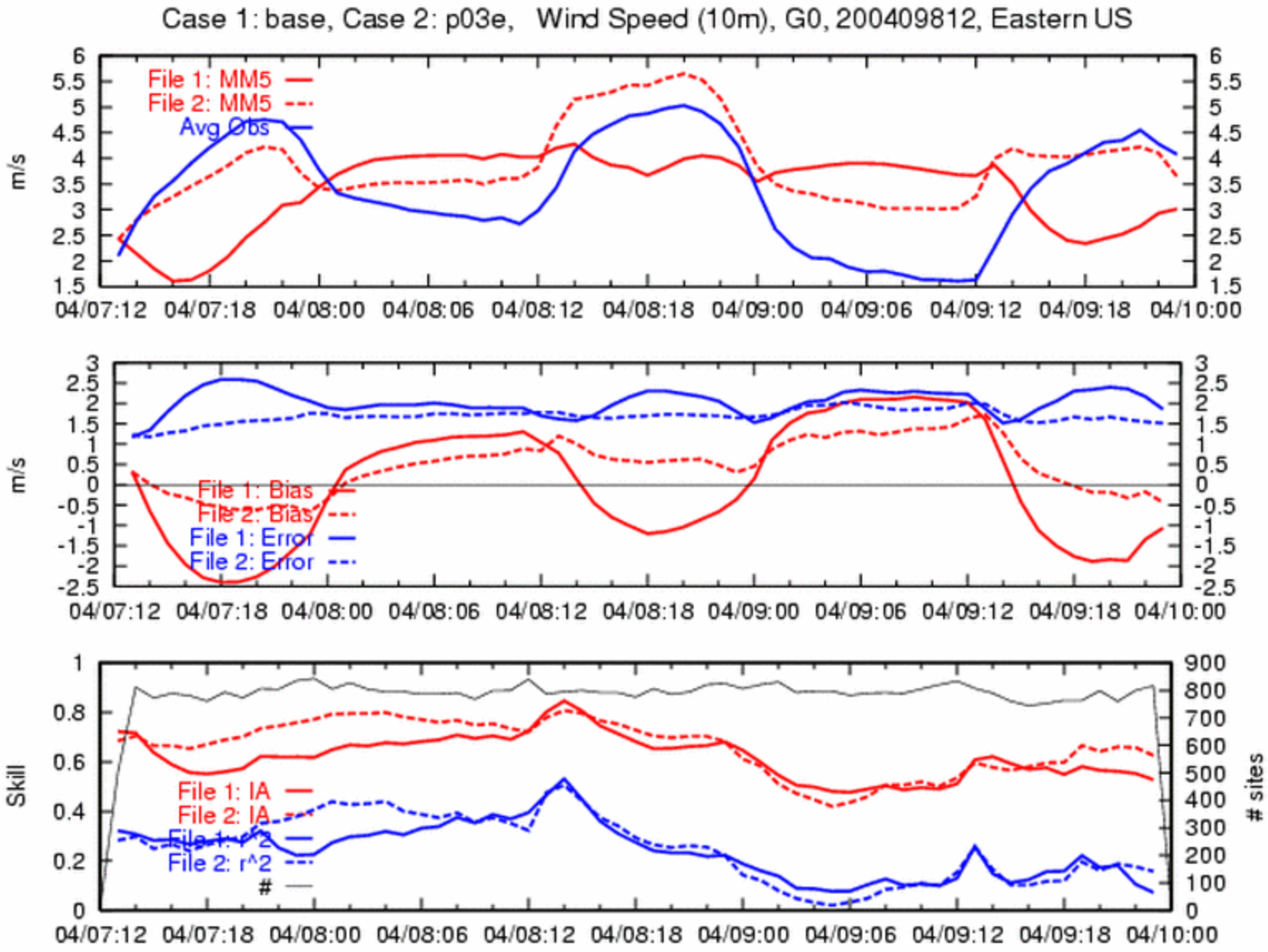
- **Like noah_mrf4d, except:**
  - **Uses the (MM5 default) top soil option in TERRAIN rather than BotSoil option. Run for episode 2 only.**

Summer noah-mrf4f stats (Episode 2, US 36km)

Total stats	bias	abserr	r2	ia	rmse
Temperature (K)	-0.02	0.00	0.000	-0.001	-0.0049
Mixing Ratio (g/kg)	0.05	-0.01	-0.001	0.000	-0.0050
Rel. Humidity (%)	-0.32	-0.13	-0.004	-0.003	-0.1298
Wind Speed (m/s)	0.00	0.00	-0.001	0.000	-0.0013
Clouds (%)	0.00	0.00	0.000	0.000	0.0101

Wind stats	bias	abserr	uerr	verr	uverr
Wind (deg, m/s)	-0.040	-0.02	-0.0010	0.0000	-0.0007

Pcp Threshold (in)	Acc	Bias	FAR	POD	CSI	ETS	TSS	HSS
0.01	0.0006	0.0051	-0.0005	0.0032	0.0018	0.0013	0.0016	0.0015
0.05	-0.0015	-0.0095	-0.0027	0.0024	-0.0006	-0.0015	-0.0006	-0.0018
0.10	-0.0020	-0.0113	-0.0034	0.0009	-0.0018	-0.0024	-0.0019	-0.0032
0.25	-0.0018	-0.0084	-0.0048	-0.0044	-0.0040	-0.0043	-0.0059	-0.0058
0.50	-0.0009	-0.0245	-0.0025	0.0030	-0.0006	-0.0008	0.0018	-0.0011
1.00	-0.0003	-0.0311	-0.0029	0.0022	-0.0006	-0.0007	0.0018	-0.0011


Case 1: base, Case 2: p03e, Wind Speed (10m), G0, 200409812, Eastern US
File 1: MM5
File 2: MM5
Avg Obs
m/s
File 1: Bias
File 2: Bias
File 1: Error
File 2: Error
m/s
File 1: IA
File 2: IA
File 1: r^2
File 2: r^2
#
Skill
sites
04/07:12 04/07:18 04/08:00 04/08:06 04/08:12 04/08:18 04/09:00 04/09:06 04/09:12 04/09:18 04/10:00

And now back to our regularly scheduled programming. . .

MM5 preferred options

- Pleim-Xiu land-surface scheme/ACM pbl
- RRTM radiation
- Kain-Fritsch 2 cloud parameterization
- Reisner 1 microphysics
  - Similar results to Reisner 2 without the computational/disk expense
- LITTLE_R rather than RAWINS
- Snow effects set to 1 (per Jon Pleim)
- Nudging as follows:
  - 2.5E-4 (winds sfc/aloft, temp aloft) at 36 km
  - 1.0E-4 (winds sfc/aloft, temp aloft) at 12 km
  - 1.0E-5 (moisture aloft at 36/12 km)