Chapter 6: Model Performance

Addendum, Feb 23, 2012

6.7 Discussion

6.7.1 Model performance summary

Multiple methods were used to evaluate the performance characteristics of this model of greater Everglades hydro-ecology. The following summarizes those performance evaluations:

6.7.1.1 Hydrology & water quality

- Water stage: median bias in predicting stage elevations was 0 cm for 82 marsh locations in the greater Everglades, whose hydroperiod ranged from continuously flooded to rarely flooded; these and other statistical metrics were comparable to the SFWMM
- Water flows: distribution of surface water chloride concentrations throughout the freshwater Everglades showed patterns of long-term flow regimes that were consistent with our understanding of major flow paths, with a median relative bias of 11% for 78 marsh and canal locations in the greater Everglades.
- Phosphorus dynamics: distribution of surface water phosphorus concentrations throughout the freshwater Everglades showed eutrophication gradients that were consistent with observations, with a median bias in predicting surface water TP concentrations of 0 ug l^{-1} for 78 marsh and canal locations in the greater Everglades, whose mean concentrations ranged from less than 10 to more than 100 ug l^{-1}.

For the addendum, the below sections (6.7.1.2 - 6.7.1.5) were added. (See original Chapter 6 for subsequent sections 6.7.2 and 6.7.3)

6.7.1.2 Addendum: detailed comparisons between model versions

When updating a model's code and/or data (e.g., ELM from v2.5 to v2.8), it is considered important that the updated model is at least as good or better in performance characteristics. With the ELM update, the (three to four, depending on the variable) overall median statistics for these three hydrologic and water quality variables showed either improvement, or were effectively the same, in v2.8 relative to v2.5 (as indicated in the original Chapter 6). Note that where there were improvements in median statistics, the changes were generally small and potentially of little "real world" significance.

While (0.25 km^2 resolution) ELM v2.8.4 performance statistics for stage, chloride, and phosphorus were improved overall relative to those of the (1 km^2 resolution), it was left up to the interested user to use the ELM v2.5 and 2.8 documentation reports to compare tables of statistics for each metric across the ca. 80 stations for the three variables. In the next three pages of this added section, we provide detailed v.2.8.4 - v.2.5.2 comparison tables for stage, chloride and phosphorus, followed by a brief discussion of some of the performance changes.

Table 1. Statistical evaluation of simulated vs. observed stage, 1981 – 2000, for ELM v2.8.4, v2.5.2, and their differences. Units of Bias (observed minus simulated) and RMSE are meters.

		Stage 1981-2000 v2.8.4					Stage 1981-2000 v2.5.2				v2.8.4 - v2.5.2			
Site	Basin	N	Bias (m)	RMSE (m)	R^2	NS Eff.	Bias (m)	RMSE (m)	R^2	NS Eff.	|Bias|	RMSE (m)	R^2	NS Eff.
1-7	WCA1	7046	0.15	0.19	0.72	-0.12	0.05	0.15	0.72	0.27	0.10	0.04	0.00	-0.39
1-8T	WCA1	6869	0.07	0.15	0.79	0.57	-0.05	0.15	0.76	0.55	0.03	0.00	0.03	0.02
1-9	WCA1	6879	0.08	0.14	0.77	0.45	-0.03	0.14	0.74	0.46	0.05	0.00	0.03	-0.02
WCA2F1	WCA2A	2259	0.07	0.17	0.79	0.61	0.11	0.18	0.82	0.57	-0.04	-0.01	-0.02	0.04
WCA2F4	WCA2A	1941	0.01	0.16	0.73	0.60	0.08	0.15	0.77	0.64	-0.06	0.01	-0.03	-0.04
WCA2E4	WCA2A	2260	0.04	0.18	0.75	0.58	0.09	0.18	0.77	0.56	-0.06	-0.01	-0.01	0.02
2A-17_B	WCA2A	7305	0.02	0.18	0.75	0.56	0.05	0.16	0.75	0.65	-0.03	0.02	0.00	-0.09
2A-300_B	WCA2A	7278	0.01	0.20	0.70	0.61	0.06	0.19	0.69	0.64	-0.05	0.01	0.01	-0.03
WCA2U1	WCA2A	2150	-0.02	0.19	0.69	0.64	0.13	0.25	0.69	0.37	-0.11	-0.06	0.01	0.26
3A-NW_B	WCA3A	7035	-0.23	0.27	0.72	-0.03	-0.02	0.14	0.73	0.72	0.22	0.13	-0.02	-0.74
3A-10_B	WCA3A	6445	-0.17	0.21	0.76	-0.02	-0.03	0.13	0.75	0.58	0.14	0.07	0.02	-0.59
3A-NE_B	WCA3A	6813	-0.03	0.22	0.69	0.68	0.02	0.21	0.70	0.69	0.01	0.00	-0.01	-0.01
3A-11_B	WCA3A	6487	0.16	0.20	0.85	0.06	0.23	0.25	0.85	-0.56	-0.07	-0.06	0.00	0.62
3A-3_G	WCA3A	7305	0.00	0.14	0.87	0.87	-0.02	0.15	0.86	0.86	-0.02	-0.01	0.01	0.01
3A-2_G	WCA3A	7145	0.01	0.11	0.88	0.86	0.05	0.12	0.87	0.83	-0.04	-0.01	0.01	0.03
3A-12_B	WCA3A	6738	-0.06	0.17	0.67	0.50	-0.02	0.16	0.65	0.56	0.04	0.01	0.02	-0.07
3A-9_B	WCA3A	6969	0.07	0.13	0.86	0.79	0.15	0.18	0.86	0.59	-0.07	-0.05	0.00	0.19
L28-2	WCA3A	4007	-0.10	0.20	0.51	0.16	0.18	0.21	0.84	0.06	-0.08	-0.01	-0.33	0.10
3A-S_B	WCA3A	6871	0.07	0.14	0.85	0.73	0.12	0.16	0.86	0.61	-0.05	-0.03	0.00	0.12
3A-4_G	WCA3A	7305	0.07	0.13	0.89	0.83	0.12	0.18	0.85	0.68	-0.06	-0.05	0.04	0.15
3A-28_G	WCA3A	7295	-0.11	0.14	0.90	0.77	-0.02	0.13	0.82	0.82	0.09	0.02	0.07	-0.05
3-99	WCA2B	3338	-0.34	0.39	0.67	-0.45	0.23	0.32	0.55	0.04	0.11	0.07	0.12	-0.49
2B-Y	WCA2B	5515	-0.53	0.61	0.82	0.04	-0.01	0.32	0.77	0.73	0.52	0.29	0.05	-0.70
3-76	WCA3B	3390	0.25	0.27	0.54	-2.36	-0.16	0.22	0.61	-1.27	0.09	0.05	-0.07	-1.09
3-71	WCA3B	3454	0.12	0.15	0.65	0.12	-0.02	0.12	0.63	0.50	0.09	0.04	0.02	-0.38
3-34	WCA3B	1633	0.05	0.10	0.84	0.75	-0.11	0.14	0.81	0.48	-0.07	-0.04	0.03	0.28
SHARK.1_H	WCA3B	6684	0.06	0.12	0.83	0.78	-0.04	0.12	0.84	0.78	0.02	0.00	0.00	-0.01
3B-SE_B	WCA3B	6029	-0.09	0.14	0.88	0.81	-0.15	0.23	0.83	0.50	-0.07	-0.09	0.04	0.31
HOLEY1	Holey L.	4041	-0.17	0.22	0.65	0.01	-0.16	0.21	0.63	0.11	0.02	0.01	0.02	-0.09
HOLEY_G	Holey L.	5599	-0.05	0.22	0.50	-0.48	-0.02	0.22	0.49	-0.49	0.03	0.00	0.01	0.01
HOLEY2	Holey L.	4046	-0.10	0.19	0.57	0.39	-0.12	0.20	0.56	0.30	-0.03	-0.01	0.01	0.08
ROTT.S	Roten. T.	5208	0.09	0.16	0.54	0.33	0.12	0.17	0.60	0.24	-0.03	-0.01	-0.06	0.09
BCNPA13	BCNP	1923	-0.14	0.22	0.49	0.14	-0.18	0.26	0.37	-0.16	-0.03	-0.04	0.12	0.30
L28.GAP	BCNP	6393	0.05	0.15	0.65	0.56	-0.09	0.18	0.53	0.31	-0.04	-0.04	0.12	0.25
3A-SW_B	BCNP/3A	6641	-0.01	0.10	0.87	0.80	0.08	0.13	0.86	0.68	-0.08	-0.03	0.01	0.13
BCNPA5	BCNP	3636	-0.06	0.14	0.72	0.54	-0.13	0.21	0.42	0.02	-0.07	-0.07	0.30	0.52
BCNPA4	BCNP	3601	0.29	0.34	0.58	-0.87	0.03	0.20	0.53	0.38	0.25	0.15	0.05	-1.25
TAMI.40M	BCNP	7305	-0.04	0.18	0.73	0.66	-0.01	0.18	0.72	0.66	0.03	0.00	0.01	0.00
BCNPA11	BCNP	3549	0.09	0.23	0.43	0.24	0.15	0.27	0.33	-0.01	-0.05	-0.04	0.10	0.25
G-618_B	ENP	7124	-0.11	0.15	0.82	0.59	-0.05	0.14	0.72	0.66	0.05	0.01	0.10	-0.07
L29	ENP	7305	-0.05	0.14	0.72	0.63	0.00	0.13	0.69	0.67	0.05	0.01	0.03	-0.04
LOOP1_H	ENP	5938	0.04	0.12	0.69	0.65	0.12	0.17	0.68	0.32	-0.08	-0.05	0.01	0.33
LOOP2_H	ENP	5972	0.14	0.21	0.73	0.39	0.17	0.23	0.70	0.24	-0.03	-0.02	0.03	0.16
NESRS3_B	ENP	5579	0.07	0.16	0.67	0.59	0.02	0.14	0.67	0.65	0.05	0.01	-0.01	-0.06
NESRS2	ENP	6228	-0.02	0.09	0.76	0.75	-0.03	0.09	0.76	0.74	-0.01	0.00	0.00	0.01
NP-201	ENP	5723	0.17	0.21	0.83	0.43	0.16	0.19	0.82	0.50	0.02	0.01	0.01	-0.07
BCNPA10	ENP	3637	-0.05	0.15	0.53	0.42	-0.10	0.17	0.53	0.24	-0.05	-0.02	0.00	0.18
NESRS1	ENP	6536	-0.06	0.10	0.76	0.65	-0.02	0.09	0.74	0.72	0.03	0.01	0.02	-0.07
NP-205	ENP	7149	0.03	0.14	0.81	0.80	0.04	0.14	0.80	0.78	-0.01	-0.01	0.01	0.02
L67EX.W	ENP	6319	0.00	0.17	0.80	0.63	0.05	0.18	0.74	0.59	-0.05	-0.01	0.06	0.04
L67EX.E_B	ENP	6187	-0.08	0.14	0.72	0.54	-0.03	0.11	0.74	0.70	0.05	0.03	-0.02	-0.16
G-620_B	ENP	6264	0.03	0.11	0.80	0.78	0.01	0.11	0.79	0.79	0.02	0.00	0.00	-0.01
NP-202	ENP	7069	0.07	0.14	0.84	0.67	0.08	0.15	0.74	0.61	-0.01	-0.01	0.09	0.06
NESRS4_B	ENP	4854	-0.04	0.11	0.71	0.59	-0.03	0.10	0.71	0.63	0.01	0.01	0.00	-0.04
G-596_B	ENP	7282	-0.25	0.31	0.59	-0.46	-0.13	0.23	0.60	0.16	0.13	0.07	-0.01	-0.62
NESRS5_B	ENP	4953	-0.02	0.08	0.77	0.68	-0.01	0.08	0.76	0.70	0.01	0.00	0.01	-0.02
G-3273	ENP	6137	-0.19	0.26	0.72	0.37	-0.18	0.25	0.75	0.44	0.01	0.02	-0.03	-0.07
L67E.S	ENP	3631	0.06	0.16	0.61	0.54	0.10	0.19	0.55	0.34	-0.04	-0.03	0.06	0.20
NP-203	ENP	7049	0.05	0.12	0.74	0.70	0.05	0.13	0.74	0.68	-0.01	0.00	0.01	0.02
G-1502	ENP	7305	-0.16	0.24	0.73	0.51	-0.13	0.22	0.75	0.61	0.03	0.03	-0.02	-0.10
NP-P33	ENP	7147	0.02	0.12	0.68	0.66	0.02	0.13	0.60	0.57	0.00	-0.02	0.07	0.09
NP-P34	ENP	6971	0.07	0.16	0.82	0.67	0.03	0.16	0.82	0.64	0.04	-0.01	0.00	0.03
NP-RG1	ENP	1570	-0.10	0.14	0.86	0.65	-0.09	0.14	0.85	0.67	0.01	0.00	0.01	-0.02
NP-206	ENP	6641	-0.08	0.22	0.72	0.65	-0.08	0.21	0.76	0.69	0.00	0.01	-0.04	-0.04
NP-RG2	ENP	1502	-0.10	0.15	0.88	0.68	-0.11	0.16	0.85	0.63	-0.01	-0.01	0.02	0.05
NP-P36	ENP	6952	0.03	0.12	0.68	0.63	0.07	0.13	0.71	0.55	-0.04	-0.01	-0.03	0.08
RUTZKE_G	ENP	2369	-0.02	0.14	0.79	0.58	-0.05	0.20	0.79	0.21	-0.03	-0.05	0.00	0.37
NP-P35	ENP	6851	-0.06	0.12	0.75	0.62	-0.14	0.20	0.79	-0.11	-0.08	-0.08	-0.04	0.73
NP-P62	ENP	6851	0.03	0.14	0.80	0.77	-0.03	0.13	0.80	0.79	0.00	0.01	0.00	-0.02
NP-P44	ENP	6440	-0.22	0.31	0.79	0.46	-0.21	0.30	0.80	0.51	0.02	0.02	-0.01	-0.05
NP-TSB	ENP	7299	-0.13	0.19	0.89	0.69	-0.16	0.22	0.79	0.56	-0.03	-0.04	0.10	0.14
NP-P72	ENP	7186	-0.23	0.30	0.78	0.41	-0.20	0.29	0.75	0.47	0.03	0.02	0.03	-0.06
NP-P38	ENP	6896	0.06	0.11	0.87	0.63	-0.09	0.14	0.87	0.44	-0.03	-0.03	0.00	0.19
SWEVER3	ENP	5330	0.04	0.10	0.81	0.49	0.20	0.25	0.68	-2.47	-0.16	-0.16	0.12	2.97
SWEVER4	ENP	5582	-0.04	0.16	0.78	-0.11	0.04	0.19	0.75	-0.58	0.00	-0.03	0.02	0.47
NP-P67	ENP	7107	0.00	0.10	0.80	0.77	0.04	0.11	0.78	0.72	-0.03	-0.01	0.02	0.05
NP-P46	ENP	6680	0.04	0.13	0.73	0.38	-0.02	0.13	0.71	0.42	0.02	0.00	0.02	-0.04
SWEVER2B	ENP	5488	-0.05	0.09	0.79	0.66	0.14	0.17	0.58	-0.33	-0.08	-0.08	0.21	0.99
NP-207	ENP	6755	0.07	0.11	0.84	0.61	0.05	0.10	0.86	0.71	0.03	0.02	-0.02	-0.10
NP-EPS	ENP	5240	0.05	0.07	0.78	0.53	-0.02	0.06	0.70	0.67	0.03	0.01	0.08	-0.14
NP-EP12R	ENP	2828	-0.03	0.06	0.73	0.63	-0.07	0.09	0.76	0.22	-0.04	-0.03	-0.03	0.41
NP-EP9R	ENP	2608	0.00	0.06	0.84	0.80	-0.12	0.13	0.75	-0.09	-0.12	-0.08	0.08	0.88
	Median:	6356	0.00	0.15	0.76	0.60	-0.01	0.17	0.75	0.56				
										# worse:	39	37	27	37
										# same/better:	43	45	55	45

Table 2. Statistical evaluation of simulated vs. observed seasonal surface water chloride concentrations, 1981 – 2000, for ELM v2.8.4, v2.5.2, and their differences. Units of Bias (observed minus simulated) and RMSE are meters.

Site	Basin	Site type	1981-2000 v2.8.4 N	ObsMean	RelBias	Bias	RMSE	1981-2000 v2.5.2 RelBias	Bias	RMSE	v2.8.4 - v2.5.2 |RelBias|	|Bias|	RMSE
X0	WCA1	Can. Trans.	10	131	0.13	17	21	0.18	24	38	0.06	-7	16
Z0	WCA1	Can. Trans.	10	133	0.14	18	23	0.19	25	40	0.05	-7	18
E0	WCA2A	Can. Trans.	14	128	0.12	16	22	0.01	1	37	0.11	14	16
F0	WCA2A	Can. Trans.	14	132	0.15	20	25	0.04	5	41	0.11	14	17
L40-1	WCA1	Canal	18	132	0.25	33	45	0.20	26	54	0.05	7	-9
L40-2	WCA1	Canal	18	80	-0.28	-22	43	-0.33	-26	59	0.05	-4	16
L7	WCA1	Canal	10	228	0.24	55	106	0.45	103	167	0.21	-48	61
S10A	WCA1	Canal	19	95	-0.24	-23	33	-0.22	-21	56	0.01	1	23
S10C	WCA1	Canal	21	131	0.10	14	30	0.11	14	53	0.00	-1	23
S10D	WCA1	Canal	33	145	0.18	27	38	0.17	24	56	0.02	2	18
S10E	WCA1	Canal	15	141	0.13	18	30	0.17	24	50	0.04	-5	20
S39	WCA1	Canal	34	106	-0.15	-16	36	-0.17	-18	56	0.03	-3	20
S11A	WCA2A	Canal	26	118	0.12	14	26	0.16	19	43	0.05	-6	16
S11B	WCA2A	Canal	27	122	0.13	16	29	0.18	22	44	0.05	-6	15
S11C	WCA2A	Canal	33	117	0.09	11	21	0.15	18	41	0.06	-7	20
S144	WCA2A	Canal	23	127	0.09	11	25	0.08	11	45	0.01	1	21
S145	WCA2A	Canal	29	121	0.07	8	21	0.07	8	44	0.00	0	23
S146	WCA2A	Canal	24	117	0.03	3	21	0.02	2	45	0.01	1	25
C123SR84	WCA3A	Canal	18	75	0.18	13	17	0.19	14	24	-0.01	-1	-7
S12A	WCA3A	Canal	33	29	-1.13	-33	36	-0.81	-24	33	0.32	9	3
S12B	WCA3A	Canal	33	39	-0.61	-24	29	-0.33	-13	28	0.28	11	1
S12C	WCA3A	Canal	34	54	-0.17	-9	22	0.04	2	33	0.13	7	10
S12D	WCA3A	Canal	34	69	0.08	6	23	0.24	16	37	0.16	-11	14
S151	WCA3A	Canal	34	98	0.20	19	29	0.25	24	39	0.05	-5	10
S333	WCA3A	Canal	33	77	0.16	12	25	0.31	24	40	0.15	-11	15
S31	WCA3B	Canal	18	89	-0.38	-34	74	0.01	1	60	0.36	33	14
X1	WCA1	Mar. Trans.	10	122	0.09	11	14	0.12	15	29	0.03	-4	16
X2	WCA1	Mar. Trans.	10	102	-0.01	-1	18	0.05	5	44	0.04	-4	26
X3	WCA1	Mar. Trans.	10	87	-0.13	-12	29	-0.30	-26	55	0.16	-14	26
X4	WCA1	Mar. Trans.	10	51	-0.02	-1	20	-0.19	-10	50	0.18	-9	30
Y4	WCA1	Mar. Trans.	10	51	-0.08	-4	27	-0.86	-44	67	0.78	-40	40
Z1	WCA1	Mar. Trans.	10	125	0.19	24	26	0.12	15	31	0.07	9	-5
Z2	WCA1	Mar. Trans.	10	108	0.08	9	18	-0.09	-10	32	-0.01	-1	14
Z3	WCA1	Mar. Trans.	10	67	0.03	2	30	-0.55	-37	63	0.53	-35	33
Z4	WCA1	Mar. Trans.	10	36	-0.18	-6	17	-0.92	-33	50	0.74	-26	33
E1	WCA2A	Mar. Trans.	14	149	0.26	39	47	-0.01	-1	94	0.25	38	47
E2	WCA2A	Mar. Trans.	14	125	0.20	25	32	-0.24	-30	55	0.03	-4	23
E3	WCA2A	Mar. Trans.	14	124	0.19	24	34	-0.23	-28	56	0.04	-4	22
E4	WCA2A	Mar. Trans.	14	122	0.16	19	25	-0.26	-31	59	0.10	-12	34
E5	WCA2A	Mar. Trans.	14	114	0.15	17	23	-0.32	-36	67	0.17	-20	44
F1	WCA2A	Mar. Trans.	12	157	0.31	49	53	0.05	8	61	0.26	40	-8
F2	WCA2A	Mar. Trans.	14	150	0.25	38	41	-0.11	-16	58	0.15	22	17
F3	WCA2A	Mar. Trans.	14	143	0.24	35	37	-0.12	-18	62	0.12	17	25
F4	WCA2A	Mar. Trans.	14	137	0.25	34	38	-0.12	-16	61	0.13	18	24
F5	WCA2A	Mar. Trans.	14	144	0.25	37	39	-0.08	-11	62	0.18	25	22
U1	WCA2A	Mar. Trans.	14	102	0.10	10	19	-0.28	-28	60	0.18	-18	41
U2	WCA2A	Mar. Trans.	14	129	0.29	37	39	-0.05	-6	51	0.24	31	12
U3	WCA2A	Mar. Trans.	14	133	0.27	35	39	-0.10	-14	58	0.16	22	19
EP	ENP	Marsh	19	155	-6.20	-964	1249	-64.21	-13229	17364	-58.01	-12265	-16115
NE1	ENP	Marsh	21	78	0.30	23	28	0.25	20	32	0.04	4	-4
P33	ENP	Marsh	22	71	0.14	10	21	0.21	15	29	-0.07	-5	-8
P34	ENP	Marsh	18	22	-1.14	-25	31	-1.15	-26	39	-0.01	-1	-8
P35	ENP	Marsh	21	130	0.62	81	144	0.48	63	223	0.14	18	-79
P36	ENP	Marsh	22	72	0.19	14	26	0.26	19	34	-0.07	-5	-9
P37	ENP	Marsh	20	30	0.32	10	17	-1.59	-48	105	-1.27	-38	-88
TSB	ENP	Marsh	22	39	0.07	3	18	0.01	1	24	0.06	2	-6
LOX10	WCA1	Marsh	6	28	-1.86	-52	60	-0.12	-3	29	1.74	49	31
LOX11	WCA1	Marsh	6	12	0.30	4	7	-0.05	-1	7	0.25	3	0
LOX12	WCA1	Marsh	6	28	-0.72	-20	23	0.02	1	15	0.70	20	8
LOX13	WCA1	Marsh	6	11	-1.00	-11	17	0.01	0	6	0.99	11	11
LOX14	WCA1	Marsh	6	21	-1.25	-26	28	-2.97	-61	67	-1.72	-36	-39
LOX15	WCA1	Marsh	6	48	-1.04	-50	57	-0.57	-28	42	0.47	23	15
LOX16	WCA1	Marsh	6	14	-5.08	-73	75	-3.60	-51	56	1.48	21	19
LOX3	WCA1	Marsh	6	37	0.42	15	19	0.34	12	38	0.08	3	-19
LOX4	WCA1	Marsh	6	68	0.02	2	36	-0.83	-57	77	-0.81	-55	-41
LOX5	WCA1	Marsh	5	18	0.60	10	11	0.34	6	12	0.26	4	-1
LOX6	WCA1	Marsh	6	41	0.02	1	18	-1.20	-52	63	-1.19	-52	-45
LOX7	WCA1	Marsh	6	28	0.61	18	18	-0.89	-26	35	-0.27	-8	-17
LOX8	WCA1	Marsh	6	15	0.57	8	9	0.07	1	8	0.51	7	1
LOX9	WCA1	Marsh	6	13	-1.09	-14	22	0.33	4	7	0.77	9	15
CA311	WCA3A	Marsh	6	30	0.12	4	6	-0.37	-11	26	-0.25	-7	-19
CA315	WCA3A	Marsh	6	34	0.37	13	14	0.25	9	20	0.12	4	-6
CA32	WCA3A	Marsh	6	51	0.17	9	28	-0.14	-7	43	0.03	2	-14
CA33	WCA3A	Marsh	6	58	-0.47	-27	29	-0.81	-43	56	-0.34	-16	-27
CA34	WCA3A	Marsh	6	56	0.06	4	10	-0.29	-17	42	-0.23	-13	-32
CA35	WCA3A	Marsh	6	33	-0.35	-11	17	-0.79	-26	38	-0.44	-15	-20
CA36	WCA3A	Marsh	6	71	0.04	3	6	-0.10	-7	26	-0.06	-4	-20
CA38	WCA3A	Marsh	6	31	0.04	1	10	-0.49	-16	28	-0.45	-14	-18
		Median All:	14	87	0.12	10	26	-0.05	-3	44	# worse	35	11
		Median Canal:	6	32	0.05	3	18	0.13	14	43	# same/better	43	67
		Median Marsh:	14	120	0.12	13	29	-0.12	-12	47			

Table 3. Statistical evaluation of simulated vs. observed seasonal surface water phosphorus concentrations, 1981 – 2000, for ELM v2.8.4, v2.5.2, and their differences. Units of Bias (observed minus simulated) and RMSE are meters.

			1981-2000 v2.8.4					1981-2000 v2.5.2			v2.8.4 - v2.5.2		
Site	Basin	Site type	N	ObsMean	RelBias	Bias	RMSE	RelBias	Bias	RMSE	|RelBias|	|Bias|	RMSE
E0	WCA1	Can. Trans.	13	86	0.06	5	34	0.20	17	36	-0.14	-12	-2
X0	WCA1	Can. Trans.	8	53	-0.34	-18	29	-0.26	-14	26	0.08	4	3
Z0	WCA1	Can. Trans.	8	60	-0.17	-10	22	-0.10	-6	19	0.07	4	3
F0	WCA2A	Can. Trans.	12	93	0.11	10	31	0.23	22	35	-0.13	-12	-4
L40-1	WCA1	Canal	20	62	-0.11	-7	30	-0.16	-10	34	-0.06	-3	-3
L40-2	WCA1	Canal	20	84	0.20	17	31	0.16	13	30	0.04	3	0
L7	WCA1	Canal	8	118	0.09	11	56	0.04	4	54	0.06	7	3
S10A	WCA1	Canal	25	54	-0.70	-38	51	-0.79	-43	60	-0.08	-5	-9
S10C	WCA1	Canal	26	81	-0.15	-12	33	-0.21	-17	41	-0.05	-4	-8
S10D	WCA1	Canal	39	99	0.20	19	40	0.11	11	37	0.08	8	2
S10E	WCA1	Canal	23	88	0.15	14	41	0.17	15	40	-0.02	-2	1
S11A	WCA2A	Canal	33	27	-0.75	-20	30	-0.49	-13	26	0.26	7	4
S11B	WCA2A	Canal	32	44	-0.02	-1	22	0.13	6	23	-0.10	-4	-1
S11C	WCA2A	Canal	39	55	0.30	17	27	0.43	23	32	-0.12	-7	-5
S144	WCA2A	Canal	29	19	-1.03	-19	28	-0.56	-11	19	0.47	9	9
S145	WCA2A	Canal	35	16	-1.25	-21	26	-0.77	-13	19	0.47	8	8
S146	WCA2A	Canal	29	16	-1.31	-21	29	-0.78	-13	20	0.53	9	9
C123SR84	WCA3A	Canal	26	46	0.40	18	24	0.48	22	27	-0.08	-4	-3
COOPERTN	WCA3A	Canal	20	11	0.22	3	4	0.35	4	5	-0.13	-1	-1
S12A	WCA3A	Canal	39	16	0.17	3	21	0.33	5	20	-0.17	-3	1
S12B	WCA3A	Canal	39	14	0.00	0	15	0.19	3	14	-0.19	-3	1
S12C	WCA3A	Canal	40	14	-0.12	-2	8	0.09	1	7	0.03	0	1
S12D	WCA3A	Canal	40	14	-0.06	-1	7	0.14	2	6	-0.08	-1	1
S151	WCA3A	Canal	40	27	0.22	6	17	0.29	8	19	-0.07	-2	-2
S333	WCA3A	Canal	39	15	0.04	1	8	0.22	3	8	-0.18	-3	0
S31	WCA3B	Canal	26	21	0.28	6	14	0.38	8	17	-0.10	-2	-3
X1	WCA1	Mar. Trans.	10	40	0.16	6	21	0.58	23	33	-0.42	-17	-12
X2	WCA1	Mar. Trans.	10	16	-0.10	-2	6	0.22	3	7	-0.11	-2	-2
X3	WCA1	Mar. Trans.	10	10	-0.28	-3	5	-0.40	-5	10	-0.12	-2	-6
X4	WCA1	Mar. Trans.	9	10	0.26	3	4	0.44	5	5	-0.18	-2	-1
Y4	WCA1	Mar. Trans.	10	12	0.66	8	14	0.31	4	13	0.36	4	1
Z1	WCA1	Mar. Trans.	10	42	0.16	7	13	0.07	3	14	0.09	4	-1
Z2	WCA1	Mar. Trans.	9	14	-1.01	-14	19	-1.35	-19	23	-0.34	-5	-4
Z3	WCA1	Mar. Trans.	10	10	0.17	2	4	-1.73	-17	19	-1.56	-15	-16
Z4	WCA1	Mar. Trans.	10	9	0.38	4	6	0.34	3	6	0.05	0	0
E1	WCA2A	Mar. Trans.	13	65	0.33	22	34	0.24	15	30	0.10	6	3
E2	WCA2A	Mar. Trans.	12	58	0.34	20	29	0.33	19	29	0.02	1	0
E3	WCA2A	Mar. Trans.	12	39	0.31	12	21	0.28	11	21	0.03	1	0
E4	WCA2A	Mar. Trans.	13	15	-0.13	-2	5	-0.28	-4	7	-0.15	-2	-2
E5	WCA2A	Mar. Trans.	13	9	-0.38	-3	6	-0.76	-6	8	-0.38	-3	-2
F1	WCA2A	Mar. Trans.	13	122	0.58	71	96	0.27	32	72	0.31	38	25
F2	WCA2A	Mar. Trans.	14	70	0.64	44	61	0.49	33	47	0.14	12	14
F3	WCA2A	Mar. Trans.	13	30	0.32	10	14	0.30	9	13	0.02	1	1
F4	WCA2A	Mar. Trans.	13	19	0.10	2	6	-0.01	0	5	0.09	2	0
F5	WCA2A	Mar. Trans.	13	11	-0.35	-4	6	-0.51	-6	8	-0.17	-2	-1
U1	WCA2A	Mar. Trans.	13	11	0.13	1	8	0.00	0	8	0.13	1	0
U2	WCA2A	Mar. Trans.	13	14	0.62	8	30	0.41	6	29	0.21	3	1
U3	WCA2A	Mar. Trans.	14	9	-0.27	-2	6	-0.45	-4	7	-0.18	-2	-2
EP	ENP	Marsh	27	6	-0.89	-5	6	-0.22	-1	3	0.67	4	3
NE1	ENP	Marsh	29	10	0.41	4	7	0.43	4	7	-0.02	0	0
P33	ENP	Marsh	30	8	-0.02	0	3	-0.03	0	3	-0.01	0	0
P34	ENP	Marsh	25	6	-1.51	-9	9	-0.91	-6	6	0.60	3	3
P35	ENP	Marsh	29	14	0.58	8	16	0.57	8	16	0.01	0	0
P36	ENP	Marsh	30	17	0.67	11	24	0.64	11	24	0.03	0	0
P37	ENP	Marsh	27	6	-0.75	-4	5	-0.66	-4	5	0.09	0	0
TSB	ENP	Marsh	30	8	-0.19	-1	4	-0.53	-4	6	-0.34	-3	-2
LOX10	WCA1	Marsh	12	10	-0.04	0	4	0.53	5	6	-0.48	-5	-2
LOX11	WCA1	Marsh	14	9	0.36	3	4	0.46	4	5	-0.10	-1	-1
LOX12	WCA1	Marsh	14	8	0.24	2	2	0.32	2	3	-0.08	-1	-1
LOX13	WCA1	Marsh	14	9	0.18	2	4	0.45	4	5	-0.27	-2	-1
LOX14	WCA1	Marsh	14	8	-0.19	-2	2	-1.22	-10	11	-1.02	-8	-9
LOX15	WCA1	Marsh	14	8	-3.06	-24	24	-1.87	-14	16	1.19	9	8
LOX16	WCA1	Marsh	14	9	-0.99	-9	9	-0.70	-6	7	0.29	3	2
LOX3	WCA1	Marsh	10	11	0.17	2	6	0.43	5	7	-0.26	-3	-1
LOX4	WCA1	Marsh	12	10	-0.60	-6	8	-0.92	-9	11	-0.32	-3	-3
LOX5	WCA1	Marsh	10	9	-0.04	0	6	0.32	3	5	-0.29	-3	1
LOX6	WCA1	Marsh	14	8	-0.41	-3	5	-0.43	-3	5	-0.02	0	1
LOX7	WCA1	Marsh	14	8	0.14	1	3	0.32	3	3	-0.18	-1	0
LOX8	WCA1	Marsh	14	9	0.04	0	5	0.31	3	4	-0.27	-2	0
LOX9	WCA1	Marsh	13	9	0.29	3	5	0.44	4	5	-0.16	-1	0
CA311	WCA3A	Marsh	14	6	-0.40	-2	3	-0.66	-4	5	-0.26	-1	-2
CA315	WCA3A	Marsh	14	6	-0.05	0	2	-0.11	-1	2	-0.05	0	0
CA32	WCA3A	Marsh	14	8	-0.06	0	3	0.13	1	2	-0.07	-1	0
CA33	WCA3A	Marsh	14	13	-1.28	-16	18	-0.46	-6	8	0.82	11	10
CA34	WCA3A	Marsh	14	10	0.10	1	4	0.21	2	4	-0.11	-1	-1
CA35	WCA3A	Marsh	14	12	-1.86	-22	23	-1.74	-21	22	0.12	1	1
CA36	WCA3A	Marsh	14	30	-0.32	-9	15	-0.13	-4	10	0.19	6	4
CA38	WCA3A	Marsh	14	8	-0.37	-3	5	-0.15	-1	4	0.22	2	2
		Median All:	14	14	0.02	0	11	0.13	2	11	# worse	33	38
		Median Canal:	28	45	0.02	0	27	0.13	4	24	# same/better	45	40
		Median Marsh:	14	10	0.01	0	6	0.10	2	7			

In the above Tables 1-3 of model-version comparisons for stage, chloride, and phosphorus, it is apparent that there was variability among sites with respect to increasing or decreasing the degree to which the model predictions matched observed data. In comparing ELM v2.5.2 with ELM v2.8.4, for each of the three variables (stage, chloride and phosphorus):

1) the median (of all stations) of each of the 3-4 performance metrics per variable for canal and for marsh stations either improved or remained essentially unchanged with the version update;

2) for each of the 3-4 performance metrics per variable, the number of stations with improved or unchanged performance in the new version was greater than the number with decline in performance;

3) the magnitude of the increase or decrease in performance did not appear vary in any discernable pattern (although the two sites in WCA-2B had poorer stage performance with the update, for reasons that are unclear).

Thus, it is apparent that the model performance was at least as good or better after the update to a finer resolution model (ELM v2.8.4) using 500 m resolution land elevation data, even without efforts to modify other data to improve model performance (relative to v2.5.2). The ELM v2.5.2 had been deemed suitable for application by multiple reviewers (including an independent panel of internationally recognized modeling experts), and the ELM v2.8.4 is likewise as suitable, if not more so due to enhanced resolution and equal or better statistical performance.

6.7.1.3 Addendum: increased resolution of land elevation data (v2.8.4)

As noted elsewhere (section 6.7.2 of Chapter 6), we effectively made no effort to correct isolated performance "problems" at a handful of locations, i.e., to adjust parameters and make other efforts to refine the calibration performance. As presented in Chapters 4 and 6, the fundamental purpose of the update to v2.8 was to accommodate a 4x finer grid resolution (1 km^2 to 0.25 km^2), (along with correcting/improving miscellaneous code and data and providing enhanced model output options).

By itself, increased resolution of land elevation data (at these scales) of any model does not necessarily improve hydrologic or ecological (water quality) performance. The very good performance characteristics of the 2x2 mile (~10 km^2 grid) SFWMM relative to observations at stage monitoring locations in the greater Everglades is a good example of the relative insensitivity of spatial scale when evaluating regional models with relatively sparse monitoring locations.

Enhanced resolution does, however, provide finer discrimination of hydro-ecological gradients that may be of interest in evaluating specific questions, particularly when those scales are accompanied by finer resolution observed data. For example, within a several-year period, it may be of significant interest to compare the movement of a nutrient "front" in WCA-2A in one scenario of water & nutrient management relative to another scenario. Halving the grid-grid distance (from 1000 to 500 m) provides that much more potential discrimination, in making relative comparisons among scenarios. Along those lines, on (somewhat rare) occasion, the enhanced resolution may allow better matching the scales of observed vs. simulated data points: i.e., when a relatively course raster grid encompasses spatial variability that may be relevant, a finer resolution grid occasionally may more effectively represent the local variation of interest.

6.7.1.4 Addendum: performance in WCA-3A ("Decomp" domain)

The ELM v2.8.4 was made available for application (see http://ecolandmod.ifas.ufl.edu/projects/ELMreg500mDecompPIR1/) to assess ecological components of the CERP Decomp Phase 1 project, which is primarily focused on changing water management infrastructure and operations in WCA-3A. The performance statistics specific to WCA-3A are highlighted in Tables 1-3, and Figure 1 shows the relationship of all of the WCA-3A stage and water quality monitoring stations relative to the canal infrastructure and the 500 m grid elevation map of ELM v2.8.4.

While the performance characteristics of the model in this hydrologic basin is very good overall (with respect to stage, chloride, and phosphorus), in the updated v2.8.4, the water quality station CA35 and nearby 3A-NW_B stage station had significantly worse performance statistics than the other locations in the basin, as did nearby stations CA33 and 3A-10_B to a lesser extent. Moreover, the performance notably declined for these particular stations during the transition from v2.5.2 to v2.8.4, with phosphorus and stage showing the largest declines in performance at CA35 and 3A-NW_B, respectively.

We noted that the ELM v2.5.2 performance for these locations appeared somewhat anomalous, relative to performance calculated for other monitoring locations associated with similar flow distributions in this and other basins. In order to have the model available for use in Decomp, we did not attempt to remedy any individual-location calibration data issues with the update to v2.8.4 (as the model utility has been demonstrated and reviewed over multiple versions over time). It appears highly likely that there are two primary components to these localized model behaviors in northwest WCA-3A:

a) the use of a receiving grid cell, instead of a receiving canal, for new water inflowing into the basin via G-155 (Figure 1), and

b) uncertain data quality for the flows and phosphorus concentrations associated with that G-155 inflow.

G-155 receiving grid cell geometry

Simply put, the model use of a receiving marsh cell instead of a spreader canal focused the new inflows from G-155 into the interior marsh, instead of distributing it further south prior to entering the marsh periphery (see Figure 1). We have no record of the original intent behind using a grid cell instead of the L-28 borrow canal (model reach ID #33) in v2.5.2, but that same approach was maintained in v2.8.4. The "real world" flow is associated with upstream flows into that ~4 km long borrow canal that distributes water to the south, and using that canal as the recipient of inflows within the would have actually been the most appropriate approach.

In the 1-km resolution model version, the receiving cell had to be placed at least one grid cell away from the grid cells associated with the canal vector (due to flow restrictions associated with the algorithm), thereby placing it more than 1 km east of the south-flowing canal. Nevertheless, that single-grid cell distance from the cells that exchange with the canal, combined with the 1-km topographic gradient, appeared to allow the canal to spread the inflow to a reasonable extent (as was the intent).

However, with the 500 m grid, the same geographic placement was used for the receiving cell (i.e., w/o adjusting for the altered grid). As can be discerned in the new, 500 m elevation map (Figure 1), the multiple grid cells that must be traversed to exchange with the borrow canal in the v2.8.4 were significantly up-gradient (up-hill), and instead the inflow from G-155 was concentrated in the marsh cells, propagating southeast from within the marsh interior. This effectively removed most of the influence of the borrow canal, and this direct-focusing of water and phosphorus loading to the interior marsh led to an inherent bias of over predicting stage and phosphorus in adjacent downstream marsh monitoring stations.

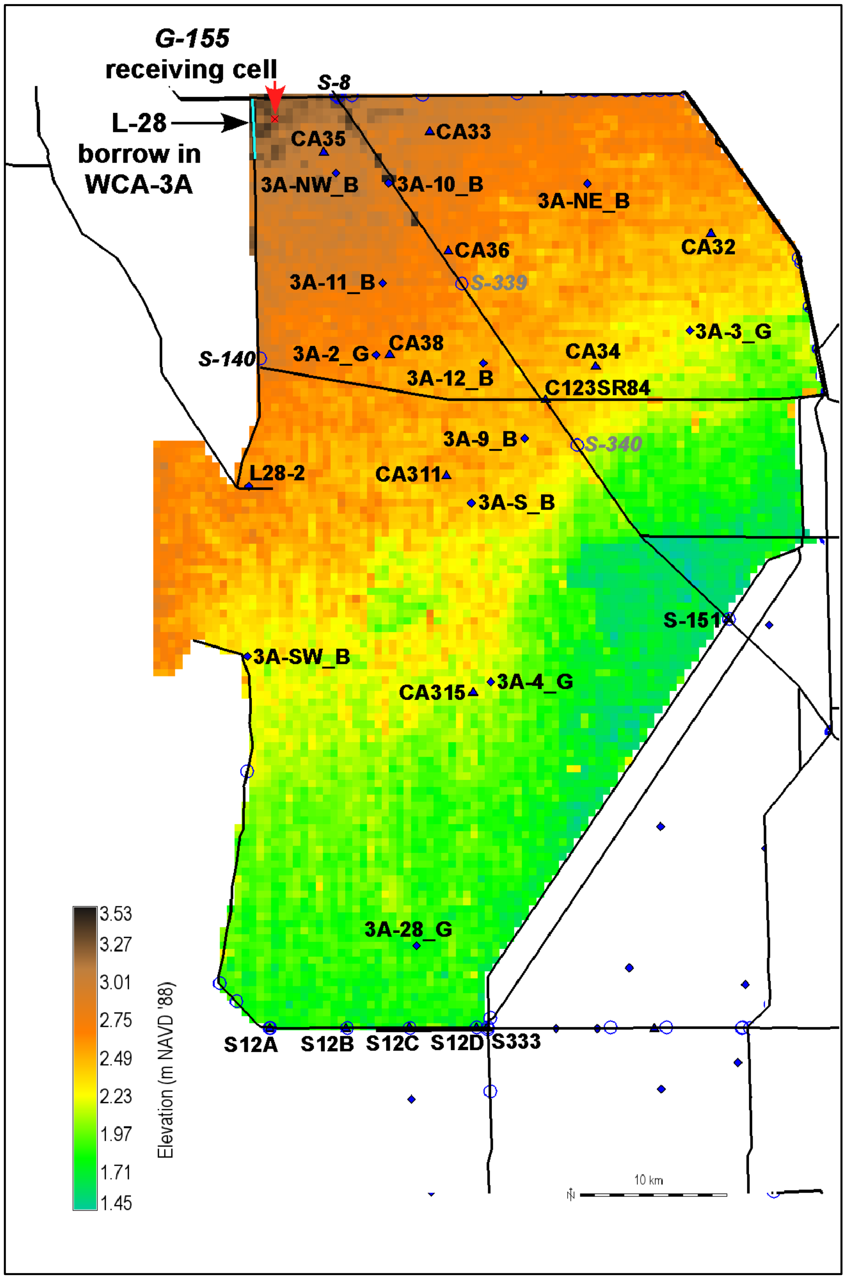

Figure 1. Land surface elevation in WCA-3A, as used in the ELM v2.8.4 500 m grid resolution model. All stage (diamond) and water quality (triangle) monitoring stations are shown, along with selected water control structures. S-8 introduces new water into the Miami Canal, and G-155 introduces new water into the northwest corner of WCA-3A. Note that the recipient of G-155 flows is a grid cell, not the ~4 km long L-28 borrow canal along the interior of the western boundary of the basin.

G-155 flow and water quality data quality

Flow is monitored at a physical G-155 structure that is 5 km west of where that flow actually enters the WCA-3A basin, and there is a reasonable degree of reliability of those observed daily flow data at the structure (relative to overall data quality at other structures). However, the 1981-2000 flow data that we have been using for G-155 has been modified (improved?) in the DBHYDRO database since they were originally obtained for use in ELM v2.5 and other versions through v2.8.4. Data at the same (quality-checked, modeling) DBKEY (P1039) on February 2012 had a sum of all flows from 1981-2000 that was more than 7% different from the data originally obtained for v2.5 (and thus v2.8) use, and has markedly different temporal signatures.

Importantly, the phosphorus concentration data associated with this flow is also different in a Feb 2012 DBHYDRO acquisition, relative to those obtained for ELM v2.5. The daily data used in the model were interpolated from monthly observed data available during implementation of ELM v2.5. However, it is apparent from Figure 2 that the daily data have much less temporal variability that the more recently acquired ca. monthly observed data. While the means of the two data sets are similar, the data currently used to drive the ELM (v2.5/v2.8) have prolonged periods with significantly higher concentrations (> 100 - 150 ppb) compared to the more recently acquired data (ca. 50 - 100 ppb). Finally, the phosphorus concentration data are not directly associated with this structure, but were all sampled at a bridge monitoring location (L3BRS) well upstream of the G-155 structure, with two other alternative canals (in addition to the canal leading to G-155) branching out from that bridge. Thus, it has always been questionable whether the water quality data used for the G-155 flow is directly relevant to that specific structure.

Synergistic effects of inflow location and input data

The net effect of these apparent updates to data stored in DBHYDRO, combined with the (ill-advised) model configuration of water and phosphorus loading into the marsh interior just upstream of monitoring stations, appear very likely to have caused the model over-predictions in the northwest tip of WCA-3A. Moreover, with these increases in modeled water and phosphorus gradients upstream of the Miami Canal, the effects of the local bias are likely propagated into effects on the Miami Canal exchanges with the marsh, tending to reduce westward exchanges from the canal, accentuating ~eastward exchanges from the canal.

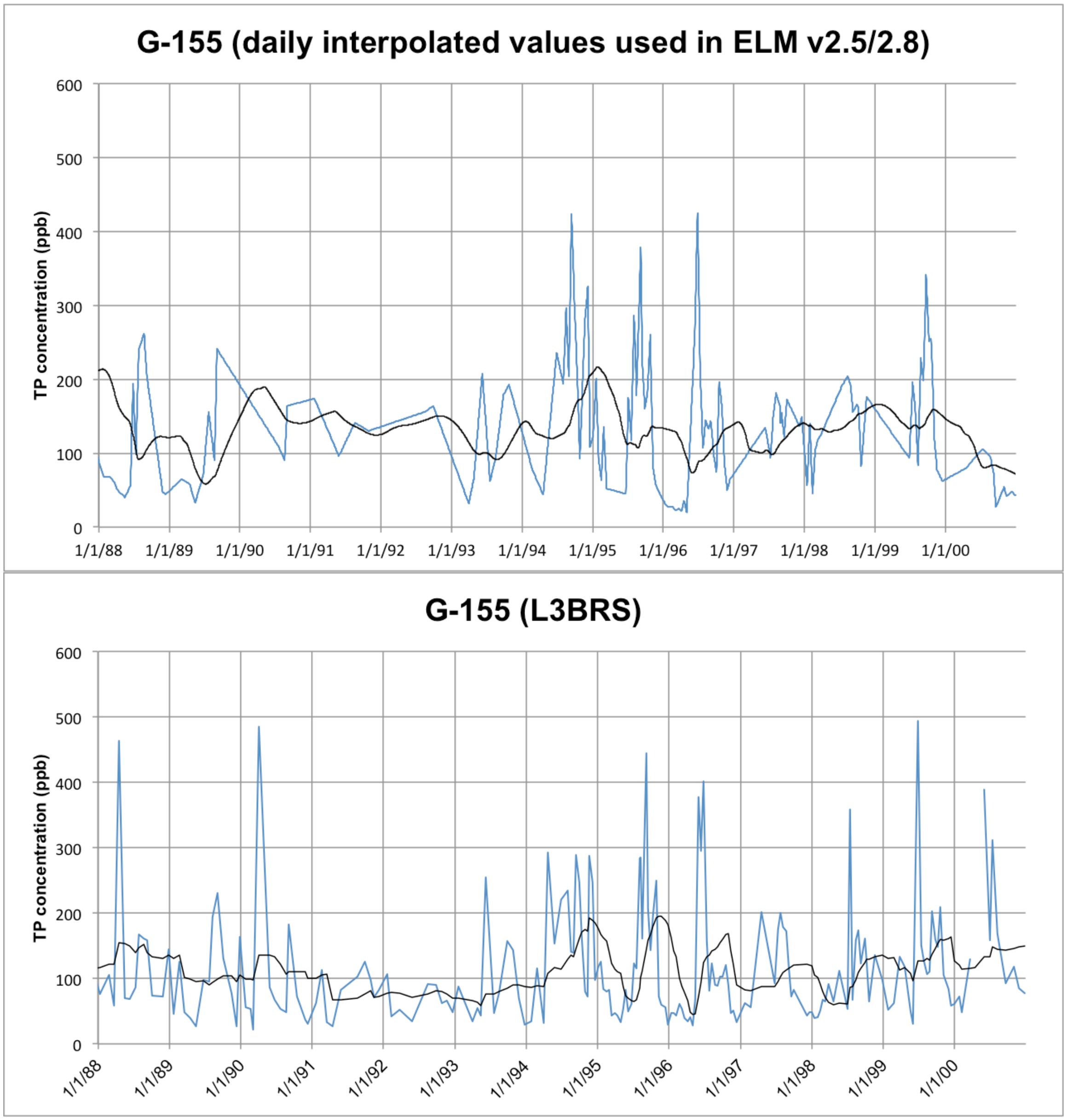

Figure 2. Different database values TP concentration
Top: Observed data as used in ELM v2.5/2.8 (daily, interpolated from earlier DBHYDRO access of L3BRS ~monthly data). 1988-2000 mean = 127, black line is 12 month moving average.
Bottom: Observed data (~monthly) from DBHYDRO (Feb 21, 2012 access). Station ID is L3BRS, upstream of (unmonitored) G-155. 1988-2000 mean = 116 ppb; black line is 12 month moving average.

6.7.1.5 Addendum: relevance of anomalous bias to future scenario applications (i.e., Decomp)

The increased bias due to the above G-155 receiving cell configuration (and historical flow/concentration input data) is restricted to the historical (calibration/validation) simulation. In all of the future Base simulations (i.e., Decomp ECB and FWO) and future Alternative simulations (i.e., Decomp Alts A-H), the receiving object of new water inflows into the model is a canal (with inflows from S-332 structures in the Everglades National Park the only exceptions). The historical model performance in this isolated area in northwest WCA-3A is relevant to stakeholders who are interested in understanding the model performance in areas of interest to their projects; it is hoped that the above discussion provides sufficient insight into the model behavior, to understand that the locally high bias in the model is an anomaly due to calibration input data choices made in the past.

The next version update of ELM will incorporate significant new data assimilation efforts. Those efforts to refine the model are ongoing, and include parameter optimization, use of finer-scale vegetation data (instead of the current version which simply filtered coarser 1-km data to the finer resolution), updating to new versions of rainfall and potential evapotranspiration input data, updating (a relatively small number) of water control structure flow and water quality input data, and numerous other refinements that will be associated with a major upgrade to the model.